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feet more, higher up, consist of massive sandstones and heavy beds of shale alternating. Just overlying the upper conglomeratic sandstone plate are variegated clay slates.

It is impossible not to see the significance of the immense development of sandrocks and pebble rocks, in the Ocoee and Chilhowee systems, underlying the Lower Silurian Dolomites, and hugging the flank of the backbone of the Continent, for a thousand miles through Virginia, North Carolina, Tennessee and Georgia, as in New Jersey and New York. It is a shore deposit on an immense scale, in a shallow sea, with a steeply inclined margin, and an Alpine range inland. No glaciers; for the conglomerates consist of rolled shingle stones; but torrents, innumerable and vehement. No large rivers; for no delta deposits of any size are apparent. A rapid degradation of the mountains was followed or stopped by a partial submergence, which deepened the sea, made the sand deposits finer, and permitted the deposit of the Lower Silurian limestones.

The reason therefore why the massive Quebec Group (Potsdam, Chilhowee and Ocoee) formation does not come up to daylight in the faults which break the middle and northwestern parts of the floor of the region under discussion, is because it thins away rapidly seaward, that is, westward, towards the Coal Area. And in this it only sets an example afterwards followed by the sandstone and conglomerate members of the great Palæozoic system: Nos. IV, IX, X, and XII the Millstone Grit.

Stated Meeting, July 19, 1872.

Present, five members.

Mr. Eli K. Price, in the Chair.

A photograph for the Album was received from Prof. Thomas Chase, of Haverford, Pa.

Letters acknowledging receipt of publications were received from the Royal Society, London (86, 87). The Royal Saxon Society (86); the Zoologico-Botanical Society, Vienna (Vols. 8 to 11 Proc., and Trans. Vols. XII, XIII, XIV, i, ii, with a request to have the set completed. On motion, referred to the Librarian); and from Dr. Hornstein, Prag. (86).

Letters of envoy were received from the Observatorio de Marina de S. Fernando, and the Physico-Medical Society in Erlangen.

Donations for the Library were received from the Belgian Academy, French Geographical Society, Italian Geological Commission, London Chemical, Geological, Asiatic and Antiquarian Societies, Meteorological Office, Nature, Old and New, Dr. Samuel Green, Silliman's Journal, American Chemist, Philadelphia Academy of Natural Sciences, Franklin Institute, Penn Monthly, American Journal of the Medical Sciences, Medical News, Baltimore Peabody Institute, Washington Philosophical Society, and Petroleum Monthly.

A paper entitled "On the Tertiary Coal and Fossils of Osino, Nevada," by Prof. Cope, was referred to the Secretaries.

Prof. Chase read a paper on "Ætherial Oscillation, the Primordial Force," and stated that certain of his predictions had been verified, which were based on his observations of the rainfall at San Francisco.

Pending nominations, Nos. 693 to 697, and new nomination, No. 698, were read.

Nominations, 693 to 696, were balloted for, and the following persons declared duly elected members of the Society:

Rev. Starr Hoyt Nichols, of Philadelphia.

Mr. Coleman Sellers, of Philadelphia.

Dr. Robert Peter, of Lexington, Kentucky.

Dr. Richard J. Lewis, of Philadelphia.

And the meeting was adjourned.

Stated Meeting, August 15, 1872.

Letters of acceptance was received from Dr. Robert Peter, dated Lexington, Ky., August 8th, and Mr. F. B. Miller, dated Royal Mint, Melbourne, May 6th, 1872.

Letters acknowledging receipt of publications were received from Mr. Peter Turner, dated Leoben, Oct. 12, 1871

(83, 84, 85); the Observatory at Prague, June 12, 1872 (86); the Royal Society, Rotterdam, Aug. 1, 1872 (86); the Royal Society, Stockholm, May 8, 1872 (XIII, i, ii, iii, XIV, i, ii, 71 to 77, and 80 to 85), and the Royal Society at Upsal, April 15, 1872 (XIV, i, ii, 83 to 85.)

Letters of envoy were received from the Royal Societies at Upsal and Stockholm, April, 1872; the Observatory at Turin, May 12, 1872, and the Hungarian Academy at Perth, Sept. 16, 1871.

Donations for the Library were received from the Hungarian, Prussian, Swedish, Belgian, and American Academies of Science; the Societies at Moscow, Upsal, Copenhagen, Bremen, Frankfort, Offenbach, Lausanne, Liverpool, and Salem, Mass.; the Bureau des Ponts, Montsouris Observatory and Revue Politique at Paris; the Royal Astronomical, Geographical and Asiatic Societies at London; Nature, the Public Library and Old and New at Boston; the American Journal of Science, Prof. Dana and Prof. Marsh, at New Haven; the New York Lyceum, Prof. James Hall and R. P. Whitfield, at Albany, the Franklin Institute, Journal of Pharmacy, Medical News and Penn Monthly, at Philadelphia; and the U. S. Bureau of the Interior.

The Librarian announced the reported death of Mirza Alexander Kasem Beg, Dr. Bujalsky (1866), and D. C. Dworjak, of St. Petersburg, members of this Society.

The following communications were received from Prof. E. D. Cope:

On a New Genus of Pleurodira, from the Eocene of Wyoming.

Descriptions of New Vertebrata, from the Bridger Group of the Eocene.

Second Account of New Vertebrata, from the Bridger Eocene.

And the meeting was adjourned.

DESCRIPTIONS OF SOME NEW VERTEBRATA FROM THE BRIDGER GROUP OF THE EOCENE.

By E. D. Cope.

(*Read before the American Philosophical Society, August* 15, 1872.)

Mesonyx obtusidens. Cope.

Represented by a large part of the skeleton of an individual of about the size of the wolf (*Canis lupus*). The lumbar vertebræ display the short acuminate, and anteriorly directed diapophyses, characteristic of carnivora, while the astragalus resembles that of the same group. The claws are flat and not curved. The molar teeth exhibit two principal lobes and a thin rudimental at one extremity. The middle lobe is a compressed cone, the posterior, a cutting edge, but medially placed, and less acute than in *Hyænodon*, and the sectorial teeth of other carnivora, forming a less specialized cutting apparatus. The canines are well developed. A premolar is stout conic, with rudimental tubercle at base.

	M.
Length of a sectorial (crown)	0.018
Greatest width	.008
Elevation of crest	.006
Length of crown of a second	.015
Width	.0065
Elevation of middle lobe	.014
Length of crown of canine	.026
Diameter near base	.014

The number of the teeth cannot be determined, owing to the injured condition of the jaw bones. The enamel is entirely smooth.

Found on the bluffs of Cottonwood Creek, Wyoming.

Triacodon aculeatus. Cope.

Established on two teeth of the molar and premolar series. The molar is subtriangular at the base of the crown, one side being convex ; the opposite angle nearly right, and the two remaining sides flat. The crown is divided into three elevated trihedral cones, one at each angle. Their adjacent angles are acute, and the angle of union is fissured, like the same point in the sectorial tooth of a carnivora. The smaller lobes are of equal elevation, but the crown of one is expanded so as to be slightly spade-shaped. The enamel is smooth.

	M.
Elevation of highest cusp	0.009
" " shorter "	.007
Long diameter base of crown	.006
" " " flat side	.005

The premolar is smaller, with shorter cusps, and one of the laterals reduced to a rudiment.

This species is near the *T. fallax* of Marsh, but the tooth he describes is narrower in proportion to its length, and has the anterior lobe little over half as high.

HYOPSODUS PYGMÆUS. Cope.

Represented by a portion of the right mandibular ramus with the penultimate and ante-penultimate molars in perfect preservation. These teeth present four cusps, of which the inner are crescentoid in section, the outer conic. They are all elevated, and the outer anterior is in both teeth compressed and bifid; it receives an oblique ridge from the inner posterior. Enamel smooth.

	Lines.
Length penultimate molar	2
Width	1.5
Depth of ramus at do	3

This is a small species of the genus, being about equal to the *Hyopsodus paulus L.* The penultimate molar in the allied species, *Lophiotherium ballardii*, Marsh, measures 3.2 lines in length.

ANOSTIRA TRIONYCHOIDES. Cope.

This species is about the size of our existing *Chrysemys picta*. It differs from the *A. ornata*, Leidy, in various respects. Thus the sculpture of the costal bones is pit-like, as in some species of *Trionyx*, instead of striate-ridged. There is no keel on the pygal bone behind. The first marginal bone is longer, and does not exhibit the prominent shoulder seen in *A. ornata*. The marginal bones are not unlike those of that species, having central small tubercles, and radiating ridges. The species is not uncommon in the Bridger beds on Cottonwood Creek, Wyoming.

ANOSTIRA ŒDEMIA. Cope.

This species is nearly twice the size of the last. It is distinguished by its peculiar ornamentation. This consists of bosses or swollen portions of an oval shape, which stand transversely to the long axis of the body, from a quarter to a half an inch apart. They sometimes form short ridges, surface otherwise smooth. Locality same as the last species.

ANOSTIRA MOLOPINA. Cope.

This species is intermediate in size between the two last described. It is distinguished from both by its ornamentation. This consists of a delicate and rather scattered impressed punctation, on the costal bones. Across this extend oblique ribs extending in a diagonal direction outward near the extremities of the costals. The width of one of the costals is M. .023. The costals in this species display no suture for the marginals, and the extremity of the rib projects a very little.

TRIONYX CONCENTRICUS. Cope.

This species is not uncommon in the Bridger sandstone. It is well characterized by its sculpture, which is coarsely and distinctly pitted. Across the costal bones run parallel ribs, which enclose between them from three to one row of pits.

	M.
Width of a costal bone near the middle	.02
Thickness " " "	.003

The carapace is thin. Besides being smaller than the *T. guttatus*, Leidy, this species differs in its longitudinal ribs.

TRIONYX THOMASII. Cope.

This tortoise is again distinguished from all those known by its sculpture, this being very delicate and obscure when compared with the thickness of the carapace. It consists of small tubercles of more or less elongate form, which may or may not inosculate; eight may be counted in M. .01. Width of a marginal costal, .02; thickness on suture, .0055. So in *T. concentrica*. The costals have very little curvature. The faintness of the ornamentation is a marked character.

Dedicated to my former teacher, Joseph Thomas, M. D., author of Lippincott's Biographical Gazetteer, the Pronouncing Gazetteer of the World, Baldwin's Gazetteer, and other important works.

Found with the *T. concentrica*, on Cottonwood Creek, Wyoming.

AXESTUS BYSSINUS. Cope

Genus et species novæ Trionychidarum.

This genus is represented by a species which is allied to *Trionyx*, but which differs in some important respects. The sternal bones are provided with an enamel stratum exterior to the usual dense layer of the bone, which is not sculptured. The post-abdominal bone has no sutural connections, but sends out tooth-like processes at its angles. The caudal vertebræ are procœlian, furnished with stout diapophyses and not very elongate; ball depressed, undivided. The cervical vertebræ are elongate and relatively very large. The claws are very large, and one at least flat and straight; the phalanges have broad trochlear surfaces, which indicate a moderate amount only of vertical movement. Both humerus and femur are curved and with extensive trochanters. The procoracoid and scapula are of equal lengths and the coracoid is much dilated distally.

Char. specif. The portions of plastron preserved are thin for the size of the animal, and all the bones are especially dense and smooth. The (?) post-abdominal has the free margins acute and serrulate. There is an (?) external gently convex edge with a long process extending backwards; and one long narrow one inwards. The enamel is white and is marked with decussating lines of osseous deposit, as in woven linen. This is not the result of wearing. The cervical vertebra is without spine; it is compressed in the middle and is without any pneumatic foramen.

	M.
Length cervical vertebra	.068
Diameter at middle	.020
" " end	.035
" caudal do. at ball	.010
Length " "	.023
" of an ungueal phalange	.043
Proximal depth do.	.013
Length post-abdominal (broken)	.180
Width do.	.120

Locality of the last.

BAENA HEBRAICA. Cope.

Established on a large and nearly complete fossilized tortoise, which lacks the posterior lobe of the plastron, and a corresponding part of the carapace. The component elements are coössified.

The costal scuta are very wide, excepting the first pair, whose posterior margin is sigmoidally flexed. The anterior vertebral is concave behind, and has convex lateral margins. The marginal scuta in front are very narrow, but the fourth on each side is suddenly widened in front to meet the suture between the first and second costal scuta. The sutures are all perfectly regular. There are only four inframarginal scuta, of which the second from front is the largest, forming, with the third, an angle projecting inwards.

The carapace and plastron are smooth, excepting in the lines of the sutures of the costal bones. In this position there is, in each case, a series of short pit-like grooves parallel to each other, and transverse to the axis of the bone, forming figures like some Hebrew letters, the Greek Π, etc.

The borders of the carapace are obtuse, and the general form is almost round. The diameter is almost eighteen inches.

This species may only be compared with the *B. undata*, Leidy, with which it agrees in having the humeral scuta crowded to the front of the plastron, and having a common centre with the gulars, which they little exceed in size. It differs in having four instead of five inframarginals, regular sutures, a differently formed first costal, wider lateral marginals, and in the smooth carapace with the peculiar sculpture mentioned.

TESTUDO HADRIANA. Cope. Spec. nov.

Indicated by two individuals, one nearly perfect, the other chiefly represented by a complete plastron.

This proves the existence of a very massive species of the terrestrial genus Testudo. The plastron presents a short wide lip in front, which is turned outwards, forming a strong angle with the plane of the upturned front of the lobe. This lobe is bordered by a thickening of the upper surface, which cuts off the basin from the lip, as a high ridge. The posterior lobe is deeply bifurcate, each post-abdominal projecting as a triangle. There is a notch at the outer angle of the femoral scute. The hyposternal bone is greatly thickened within the margin above, and an elevated ridge bounds the basin of the plastron behind, as before. The middle of the plastron is thin.

The carapace is without marked keel or serrations. It is remarkable for its expanded and truncate anterior outline, which is nearly straight between two lateral obtuse angles.

Length carapace, M. .750 = 29 inches; width, .630.

The marginal scuta are narrow, and there is a large nuchal plate.

Same locality as the last.

PALÆOTHECA POLYCYPHA. Cope.

This genus and species of tortoises are indicated by vertebral, costal

and marginal bones of very small individuals. These bones are, however, not only thoroughly ossified, but are very stout, indicating the adult age of the animal. The deeply impressed scutal sutures and heavy proportions, as well as the elevated carina of the carapace, indicate affinity with *Cistudo*, or perhaps, *Testudo*. As another generic character, it may be noted that the vertebral bones are subquadrate, and support the neural canal without intervening lamina.

The carina of the carapace is abruptly interrupted occasionally; sometimes with, sometimes without, a pair of pits, one on each side. The marginal bones are well recurved, and the scutal sutures are deeply impressed on them.

	M.
Length of vertebral bone	.009
Width " "	.0085
Length marginal "	.01

This is the least of the tortoises of the Bridger Formation.

PALÆOTHECA TERRESTRIS. Cope.

Represented by three individuals, one of which may be regarded as the type. They are all thinner than the *P. polycypha*, and larger, being about equal to the *Aromochelys odoratus* of our ponds.

In the type specimen the carina of the vertebral bones is interrupted by a deep sutural groove, which is less pit-like than in *P. polycypha*. The bone itself is broader than long, being, perhaps, from the hinder part of the carapace. The clavicular (episternal) bone is preserved. It is characterized by the considerable and abrupt projection of that part enclosed by the gular scutum, which resembles what is sometimes seen in *Testudo*. The edge of this part is entire and acute. The posterior part of the projection forms a step-like prominence behind, on the superior or inner face. The bone is almost as wide as long, and the mesosternal causes a very slight median truncation, but overlapped much on the inner side. The gular dermal suture does not reach it.

	M.
Length vertebral bone	.009
Width " "	.018
Length episternal	.02
Width " (transverse to axis of body)	.017
Width of a costal	.011
Thickness proximally	.003

In a second specimen, a strong groove is seen to bound the lip of the front lobe of the plastron as in the species of *Notomorpha*. In it the marginal is seen to be stout, a little recurved, and sharp-edged. A vertebral differs from those described in being longer than wide.

In a third individual the gular lip is not so prominent as in the type, and the mesosternal bone truncates the clavicular extensively giving it thus a more elongate form. The gular scuta expands to its front margin. The marginal bone is stout and sharp edged, and is not so deeply impressed by the dermal suture, as in *P. polycypha*.

Length episternal	.016
Width "	.026
Length marginal	.011
Width "	.016

The three specimens are from the bluffs of Cottonwood Creek, Wyoming.

NAOCEPHALUS PORRECTUS. Cope.

Gen. et. sp. nov. Lacertiliarum.

Established on an incomplete cranium, with vertebræ found associated. No teeth are preserved, nor any part of the mandible. The remaining portions of the cranium are, however, highly characteristic.

The occipital descends posteriorly, and bears a pair of lateral ridges, which converge rapidly posteriorly. This bone is united with the parietal by suture, which is transverse; its outline is rectangular, so as almost to reach the frontals, which are prolonged backwards on each side the parietal, leaving but a narrow exposure of the posterior processes of the parietal. These extend backward, and are broken off in the specimen, but they probably formed parts of arches. The parietal is single, and there is no parietal fontanelle. The bone is triangular in outline with the apex anterior, dividing the frontals. These are contracted at the orbits, and have a projecting superciliary head; anteriorly they are thickened. The postfrontals are of remarkable form. They are massive, and compressed from before backwards; they rise considerably above the level of the front, and bear on their summits a cotyloid cavity, which is transverse to the axis of the cranium; the use of this projection is obscure. There is an exoccipital foramen, and a large one in the posterior part of the frontal opposite the postfrontal elevation.

The sphenoid is a compressed keel-shaped bone, rounded below, and with broad alæ along much of its length. The occipital condyle is subcordate depressed in outline, with a vertical obtuse angle in the middle and the sides somewhat plane.

A dorsal vertebra preserved has a single vertical capitular process, and a short hypapophysis. The neural canal is large, and the neurapophyses are attached by sutures. The cup is nearly round, very slightly transverse, and in vertical plane.

The cranium is smooth above, except the anterior part of the frontals, which are finely rugose.

This genus is more or less allied to the *Thecoglossa*, but better material will be requisite to decide the question of affinities fully.

Found with the preceding specimens.

	M.
Width cranium at postfrontals	.072
" parietal behind	.012
Depth postfrontal	.018
" pre-sphenoid anteriorly	.014
Diameter dorsal vertebra (cup)	.007

This genus differs from *Glyptosaurus*, Marsh, in the total lack of cranial shields, and from *Saniva*, Leidy, in the nearly round vertebral centra.

SECOND ACCOUNT OF NEW VERTEBRATA FROM THE BRIDGER EOCENE.

By Edward D. Cope.

(*Read before the American Philosophical Society, August* 15, 1872.)

Helotherium procyoninum. Cope. Spec. nov.

This species is distinguished from those already known as pertaining to this genus, by its small size, as it did not much exceed the raccoon in dimensions. The size of a right superior molar is as follows:

	M.
Length	0.007
Width posterior	.0085
" anterior	.006

The crown presents four tubercles, of which the inner are flat on the posterior, the outer flat on the external side. The posterior external has a small posterior supplementary lobe, and a low tubercle intervenes between the two posterior. An anterior and a posterior cingulum. Enamel smooth.

Stypolophus pungens. Cope.

Gen. et spec. nov.

This genus is supposed to embrace a small species of carnivorous animal found by the writer in the Eocene formation of the Bridger Group. It is represented by the posterior portion of the left mandibular ramus, which contains the last two molars.

The generic characters are seen in the composition of these molars, which have but two roots, and a posterior table, as is seen in tubercular molars of some *mustelidæ*. The anterior two-thirds of the crown is composed of conic cusps. On the last molars these are in two series, two lower, of the inner, and one more elevated, of the outer, opposite the interval between the outer. Its outer face is regularly convex, but its posterior forms, with that of the outer series, a single flat vertical plane, which forms a sharp angle with the inner and outer faces of the cusps.

The structure is, in general, somewhat like that of *Mesonyx*, Cope, but the lack of cutting edge on the posterior lobe, and the two rows of tubercles separates it at once. Dr. Leidy describes *Sinopa* as having a sectorial tooth, as in ordinary *Carnivora*, with an interior cusp, hence it is not probably the present form, although this species was about the size of the *S. rapax*.

The enamel is smooth. The measurements are:

	M.
Depth ramus at last molar	0.011
Length last molar	.0072
Width " posteriorly	.0040
Height inner tubercle	.0062
" external " (anterior)	.0040

This species was about the size of the gray fox.

From the bluffs of Cottonwood Creek, Wyoming.

PANTOLESTES LONGICAUDUS. Cope.

Gen. et sp. nov.

This form is one of those mixed types which are so abundant in the Bridger Group. Its dental formula is M. 3, P. M. 3; c. 1, incisors unknown. The molars in the only specimen known are so worn as to preclude exact description. They evidently possessed anterior and posterior lobes, separated by a valley, which was most expanded on the inner side. The last molar exhibits a projecting keel posteriorly, which probably supported a small tubercle. The three premolars are all two-rooted and compressed in form. The last presents a crown composed of one large anterior compressed cusp, and a much lower posterior one. There is a slight cingulum in front. The canine is lost, but its alveolus indicates that it was a stout tooth.

So far as the known dental structure goes, this genus resembles nearly the *Notharctus* of Leidy (*Limnotherium* of Marsh), but possesses one premolar tooth less.

The mandibular ramus is quite slender, and there is a large foramen below the first true molar. The masseteric fossa is pronounced.

	M.
Length of dental series to canine	0.0280
" " three molars	.0140
" " second "	.0041
Width " " "	.0030

There were found associated with this jaw some caudal vertebræ of very attenuated form, which point to the possession of a long tail by this animal. One of these displays six short processes arranged round the articular extremity, the neural arch not being completed.

	M.
Length	0.016
Proximal diameter	.003
Median "	.0018

PSEUDOTOMUS HIANS. Cope

Gen. et sp. nov.

This form is interesting as the only member of the Edentate order yet discovered in our earlier Tertiary formations. It is represented by a species of which a nearly perfect cranium is in my possession. This is about the size of an agonti, and is of a depressed form. It has a thin molar and zygomatic arch, but no postorbital. There is a large suborbital foramen. The dentition consists of two pairs of long curved teeth, having much the form and position of the cutting teeth of *Rodentia*. These are placed widely apart in the upper jaw, allowing space for the greater portion of the premaxillary between them. The mandibular cutters are less widely separated by a narrow prolongation of the symphysis. The exposure of the tooth is lateral, its direction nearly anterior. It projects anteriorly very little beyond the symphysis, and has a horizontal triturating surface below the level of the latter. Neither pair of cutting teeth

are faced with enamel, but have only smooth cementum without sculpture. There are no molars, but the inferior face of the maxillary bone is rugose as though alveoli had been absorbed. There are traces of very shallow alveoli.

The cast of the brain indicates smooth oval hemispheres which leave the cerebellum and olfactory lobes entirely exposed. The latter are ovoid and expanded laterally.

The cranium is depressed, and has a trace of interparietal crest. The anterior margin of the temporal fossa is marked by a curved angle on each side of the frontal bone. The supra-orbital arch is very short.

This curious animal reminds me of a small *Megalonyx* with flattened cranium. The cutting teeth above are, however, more like those of rodents.

	M.
Length cranium (3.5 in.)	0.090
Width " (without zygomas)	.040
" " near end of nasals	.027
" upper cutting tooth	.007
Depth " " "	.0085
Length exposed part lower tooth	.009
Width " " " "	.006

HADRIANUS OCTONARIA. Cope.

Gen. et sp. nov.

This is a genus of true *Testudinidæ*, designed to include those with double anal scuta, and posterior lobe of the plastron bifurcate. In addition to the species above named, the *H. quadratus* (*Testudo hadriana*, Cope), and probably the species to which belongs a small piece named by Leidy, *T. corsoni*, pertain to the genus.

The *H. octonarius* is distinguished from its congener in many ways. It is of elongate form, strongly contracted at the bridges, but expanded and arched above the limbs. The carapace in quite convex. The plastron has the posterior lobe emarginate rather than bifurcate, as seen in *H. quadratus*. Each projection represents a right-angled triangle rather than a wedge. The anterior lobe presents an elongate lip, which is expanded, and slightly emarginate at the end. The mesosternal bone is heart-shaped, the posterior emargination being wide and deep.

The anterior margin of the carapace is somewhat flared above the limbs. The nuchal scutum is very narrow transversely, but elongate. The carapace descends and is incurved in the middle of the posterior margin.

	M.
Length (below)	.730
Width at middle	.437
" at hind limbs	.525

This species differs from the *H. quadratus* in many important points. It is perhaps the largest of our extinct land tortoises, and is founded on a beautifully perfect specimen from the bluffs of Cottonwood Creek.

THIRD ACCOUNT OF NEW VERTEBRATA FROM THE BRIDGER EOCENE OF WYOMING TERRITORY.

By Edward D. Cope.

(*Read before the American Philosophical Society, September* 19, 1872.)

STYPOLOPHUS INSECTIVORUS. Cope. Sp. nov.

Represented by a posterior molar and a premolar of the right side of an animal less than half the size of the *S. pungens*, Cope. The molar presents three anterior trihedral acute tubercles, of which, one is exterior and more elevated than the others. Its posterior plane forms one transverse face with that of the inner posterior. The posterior tubercular heel is low, and supports an oblique ridge which bounds a deep groove behind the outer cusp, no doubt to receive that of the upper jaw. This arrangement is not seen in *S. pungens*. The premolar is a flat cone with faint traces of a tubercle behind and cingulum on inner side.

	M.
Length crown molar	0.0050
Height inner cusp	.0040
Length heel	.0025
Width crown	.0030
Height crown premolar	.0040
Length " "	.0040

Found in the Eocene Bad Lands of Black's Fork, by the writer.

STYPOLOPHUS BREVICALCARATUS. Cope. Sp. nov.

Established on a portion of the left mandibular ramus, containing the penultimate and ante-penultimate molars, of an animal of larger size than the type of the genus *S. pungens*. The molars have the general characters of the corresponding ones of that species, but differ in their greater elevation in comparison with their length, and the greater convexity of the outer side. The shortness is occasioned by the abbreviation of the heel, which in the last molar present, is very small and flat, without keel or tubercle on its surface. That of the molar preceding it is larger, and presents in its elevated outer margin, a trace of the keel seen in the smallest species. Enamel smooth.

	M.
Length of two molars	0.016
" " penultimate crown	.008
Width " " "	.0047
Length " " heel	.002

There is some relation between *Stypolophus* and *Triacodon*, Marsh. If the heel of the molars of the former were wanting, they would be those of the latter. The premolars might be supposed to have this structure, but the form seen in *S. insectivorus* disproves this view. In fact, I have seen both molars and premolars of *Triacodon aculeatus*, Cope, and the former lack the heel of the *Stypolophi* entirely.

MIACIS PARVIVORUS. Cope. Gen. et sp. nov.

Established on a portion of the right ramus mandibuli, containing portions of three molars, the penultimate being perfect. As in *Canidæ*, the molars diminish in size posteriorly, the last being single-rooted, the penultimate being two-rooted. The structure of that tooth is approximately that of *Stypolophus*, *i. e.*, with three trihedral cusps in front and a heel behind, but the cusps are of equal height, and their point of union not raised above the surface of the heel. This is a valley bounded by a sharp margin which is incurved to the outer cusp, leaving a vertical groove on the outer side, as in *Stypolophus* sp. This genus further differs from that one in the single-rooted small tubercular posterior molar, which is wanting in that one. The ante-penultimate molar is much larger than the penultimate. The crown of the latter is laterally expanded, and bears a cingulum at the base antero-externally. Enamel smooth.

	M.
Depth ramus at penultimate molar	0.0080
Length crown of " "	.0040
Elevation " " "	.0025
Width " " "	.0033

Found on Black's Fork of Green River. An ally of *Stypolophus* and *Triacodon*.

TOMITHERIUM ROSTRATUM. Cope. Gen. et sp. nov.

Allied to *Notharctus*, Leidy. Dental formula $\frac{3}{2}\frac{1}{1}\frac{4}{4}\frac{2}{3}$, in an uninterrupted series. Last molars with five tubercles, others with four; all low and slightly alternating, the outer wearing into crescents. Canines quite small. Incisors very prominent, the median pair with transverse cutting edges. Symphysis coössified, projecting in front.

I base the distinction between this genus and *Notharctus* on the small canine, and the sub-horizontal position of the incisors; believing that when other portions of the skeleton are studied, other differences will appear. This, I have the opportunity of doing with material now in my hands.

The adjacent horns of the two outer crescents unite with the anterior outer tubercle; the posterior outer is insignificant. There is a projection but no tubercle in front of the outer anterior tubercle. The first and second premolars have but one root, the base of the second being about the size of the base of the canine. The latter are cylindric at base. The incisors form a parabolic outline, and have entire edges, the middle pair transverse ones. Enamel generally smooth, premolars somewhat striate; an indistinct inner cingulum.

	M.
Length of entire dental series (straight)	0.044
" symphysis mandibuli	.020
Depth ramus at second molar	.010
Length crown of " "	.006

	M.
Width crown of second molar	.0045
" between two " "	.014
" " " canines	.005

From near Black's Fork of Green River.

I would refer to *Notharctus*, my *Lophiotherium vasachiense*, adding the fifth species to the genus. These are *N. gracilis*, Marsh, *N. tyrannus*, Marsh, *N. tenebrosus*, Leidy, *N. robustior*, Leidy, and *N. vasachiensis*, Cope.

HADRIANUS ALLABIATUS. Cope.

This large land tortoise is nearer in general form to the *H. quadratus* than to the *H. octonarius*, but differs from both in the absence of the projecting lip of the anterior lobe of the plastron, which is thus simply truncate. The mesosternum is not cordate, but has much the shape of that of *H. quadratus*, that is, rhombic. The scutal sutures are deeply impressed. The plastron is strongly concave. Carapace without irregularities of the surface. Length eighteen inches.

From the Bad Lands of Cottonwood Creek, Wyoming.

EMYS LATILABIATUS. Cope.

Represented by a perfect specimen of a tortoise of a broadly oval form, and somewhat terrestrial habit. Its prominent characters are to be seen in the plastron, of which the posterior lobe is deeply bifurcate. The anterior lobe is peculiar in the unusual width of the lip-like projection of the clavicular ("episternal") bone, which is twice as wide as in *E. Wyomingensis*, and not prominent. Bones all smooth; margins of lobes of plastron thickened. Length of shell, one foot.

	M.
Width of lip of plastron	.06
Depth of posterior notch	.02

From near Black's Fork of Green River.

PROTAGRAS LACUSTRIS. Cope.

Gen. et sp. nov.

A serpent of about the size of the existing "Pine Snake" (*Pityophis melanoleucus*), and allied to the water-snakes of *Tropidonotus* and allied genera.

A vertebra before me has the longitudinal hypapophysial groove of that group, which terminates in a very obtuse point. The ball looks extensively upwards. The upper articular extremity of the parapophysis is short and obtuse, and the inferior equally so, and directed shortly downwards. The articular face being continuous with each other. It sends an obtuse keel backwards, which terminates in front of the ball. The angle connecting the diapophysis and zygapophyses is strong, while the former was narrow; in the specimens it is broken.

	M.
Length of centrum below	0.009
Depth to base neural spine, in front	.011
Width cup	.0054
Depth "	.0045
Expanse parapophyses above	.012
" " below	.008

From the Bad Lands of Cottonwood Creek, Wyoming.

ON A NEW GENUS OF PLEURODIRA FROM THE EOCENE OF WYOMING.

By Edward D. Cope.

(*Read before the American Philosophical Society, Aug.* 15, 1872.)

The following observations are made with a view of establishing the stratigraphic position of the genus of tortoises described below. They were made by the writer while prosecuting a palæontological investigation of the Tertiaries of Wyoming for Dr. F. V. Hayden's Geological Survey of the Territories.

The strata exposed along the northern and eastern shores of Bear River, consist of alternate sandstone, argillaceous, and conglomerate rocks of the Wahsatch Group of Hayden. They dip to the northeastward. At the coal mines below (*i. e.*, N. W. of) Evanstown, the series is capped by a heavy bed of conglomerate. At a point seven miles above (*i. e.*, S. E. of) Evanstown, the strata appear in the following order: (1.) an argillaceous rock just appearing above the river level at high water; (2.) 25 feet of sandstone; (3.) a nodular argillaceous rock of a red and ochreous color, 15 feet; (4.) 10 feet of coarse conglomerate; (5.) 80 feet of sandstones and clays.

At a point eleven miles above Evanstown, the conglomerate has descended from view, and the bluffs of 300 feet in height, consist of the upper members of the group, viz.: red and white argillaceous beds; sandstone four to six feet in thickness; a red and white argillaceous stratum, at least forty feet; sandstone 3-4 feet, and a capping of a hard, brittle, ash-colored clay rock on the highest points. Ascending five miles further to the N. E., the strata are observed to dip in a direction opposed to those at Evanstown, rising gently to the N. E. One of the heavier sandstone strata is exposed about half way up the bluffs, and is visible in the side ravines. Crossing one of these, and climbing the opposite spur, a sandstone identical lithologically with those just described, is seen standing vertically; and succeeding spurs are crowned with the edges of the succeeding sandstone beds standing high in the air. Nearly opposite Beartown, a mile eastward on the Union Pacific Railroad, these vertical sandstones pass into a conglomerate, one of the strata being composed equally of both, a gradual lithological transition being exhibited.

The nature of the flexure of these strata is somewhat obscure. The succession of vertical strata is quite similar to that already noted as seen in the bluffs of Evanstown, and the conglomerate would thus be regarded as the superior member. Dr. Hayden, however, describes them as contiguous to cretaceous strata further east.

We are assisted in concluding as to whether these beds which descend abruptly belong to the Wahsatch Group, by a consideration of the curious strata exhibited in the two railroad cuts just N. W. of Beartown, already described and figured by Dr. Hayden, in his report on the Geology of Wyoming, 1870, p. 150–153. In these, numerous thin strata, horizontal on the western end of the exposures, are suddenly decurved and become vertical to the eastward, both directions coinciding with those of the heavier and higher beds which compose the bluffs and ridges just described. That the whole is an anticlinal with the opposite strata of a very unequal dip, is rendered probable by the miniature exhibition seen in the section of the lower beds in the railroad cut.

The Wahsatch beds have been described by Dr. Hayden as wanting in vertebrate fossils. My assistant, Professor Garman, and myself succeeded, however, in discovering a number of species in the upper red and white strata on the bluffs eleven miles S. E. of Evanstown, or near the bend of Bear River. They occurred here on the upper, and upper middle portions, of the exposure. Extending our observations to the ridges of bluffs further to the southward, we found the same strata producing similar, and in several cases the same, fossils. They appeared lower down on the exposures, consistently with the dip of the strata, though a few were found near the top of these, also.

The species obtained were as follows:

1. Part femur of an ungulate, as large as *Palæosyops paludosus*.
2. End tibia of a Perissodactyle mammal.
3. *Notharctus vassacciensis*, Cope, sp. nov.
4. Dermal scuta of crocodile.
5. Fragments of a Crocodilian, perhaps *C. xiphodon*.
6. Fragments of a *Trionyx*, near *Tr. guttatus*.
7. *Notomorpha testudinea*, gen. nov. of tortoises.
8. " *gravis*, sp. nov.
9. " *garmanii*, sp. nov.
10. Fragments of an unknown reptile.
11. *Lepidosteus* scuta, perhaps like *L. glaber*.

12 and 13. Two species of Unio.

The specimens are all more or less fragmentary, and vary in color from nearly white to iron-rust color. The only ones whose specific characters are sufficiently preserved for description are those of the new genus *Notomorpha*. The facies resulting from the association of *Lepidosteus*, *C. xiphodon* and the mammals, is that of the Eocene of the Bridger Group on the eastern side of the Wahsatch. The new genus described has no Tertiary or Cretaceous relationships; yet the only Pleurodira yet

found on this continent are Cretaceous, and the mode of attachment of pubis in these species resembles nearly that seen in *Notomorpha*, both differing from most recent genera in this respect.

NOTHARCTUS VASACCIENSIS. Cope. sp. nov.

Represented by a portion of the left ramus of the lower jaw, containing one tooth in perfect preservation. The structure of this indicates it to be the second true molar, and presents certain features of distinction from the same tooth of the *Lophiotherium sylvaticum*, described by Dr. Leidy. The crown presents four tubercles which are arranged in pairs, the separation between the right and left lobe of each being slight, thus giving the tooth the appearance of having two transverse crests as in *Hyrachyus*. The two anterior and outer posterior tubercles are fissured by wearing, but the inner posterior consists of two acute crests which meet, presenting an acute angle towards the adjoining tubercle. The outer posterior tubercle sends a descending crest obliquely to the base of the inner anterior tubercle as in *L. sylvaticum*. A small tubercle occupies the space behind the interval between the posterior tubercles and gives origin to a cingulum which passes round the bases of the outer tubercles. It extends round the front of the tooth to the outer anterior tubercle. Wear would produce small angular crescents from the two posterior and the outer anterior tubercle. Greatest length of crown, M 0.008; width, .006. The enamel of the tubercles is rugose.

This ungulate was of about the size of the *L. sylvaticum*, or equal to the raccoon. It differs considerably from that species in the less isolation of the tubercles of the molar, and the crescentic form of the inner posterior.

Found by Samuel W. Garman, in the strata of the Wahsatch Group, N. E. of Evanstown, Wyoming.

NOTOMORPHA. Cope.

This form is one of the *Pleurodira*, and differs from most of those already known in the recent and fossil states, in having many features relating it to a terrestrial rather than an aquatic life. The elements of the carapace and plastron are massive, and the former was well arched; both exhibit well defined grooves for the sutures of the dermal scuta. The mesosternum is broad ovate, and the bones of the plastron are united by immoveable sutures. The elevated lateral processes of the hyo and hyposternal bones, are not broad, and unite by suture with the lower plate of the first and last bridge-marginal bones. They are thus recurved in both cases, but none of the ribs indicate any sutural union, as is seen in various genera. The costal bones unite with the marginals by serrate suture.

In one species a large intergular scutum has left its impression, the gulars being lateral and rather small. The anterior lobe of the plastron is emarginate.

The sutural union of the pubis with the xiphisternum is by an elongate

groove in a longitudinal elevation of the bone, much as in the Cretaceous genus, *Taphrosphys*, Cope. The point of attachment of the ischium is not observed nor is the posterior lobe of the plastron observed in any of the specimens. The external part of the hypoxiphisternal suture extends very obliquely backwards. The pubic suture-groove diverges very little from a line parallel with the common xiphisternal suture.

Of limb bones several fragments were found in connection with the *N. testudinea*, but are too large to be referred to that species. One is the extremity of a femur, which had a round shaft and but little curvature. The other is a proximal end, with a flat, wide trochanter, separated from the head by a deep notch, and with a slender curved shaft.

The genera of Pleurodira, which simulate land tortoises most, are found in Africa. They are *Sternothærus* and *Pelomedusa*. They are different enough from *Notomorpha*, the former in its hinged, ten-plated plastron, the latter in its intercalated bone of the plastron. The present form is, therefore, of interest in various ways. It is the first Pleurodira tortoise found west of New Jersey, and is the first of that division known to exist in the Tertiary formations of North America. As compared with those from the Cretaceous, it is distinct in many respects.

Specimens of this genus are more abundant than any other fossils in the localities in question. In two of the individuals, both xiphisternal bones are preserved; in one, the mesosternal; in two, the episternals, etc. Three species appear to be represented by my specimens, which vary from the size of the salt-marsh terrapin, *Malaclemmys palustris*, to that of the Mississippi snapper, *Macrochelys lacertina*.

NOTOMORPHA TESTUDINEA. Cope. spec. nov.

Represented by portions of four or more individuals. In one of these the anterior lobe of the plastron is in part preserved. The mesosternum is a transverse oval, the posterior margin regularly convex, the anterior with three equal borders. The median of these is concave. The sutures are radiating, and the groove separating the humeral scuta, appears to traverse the entire length of the bone. The outer surface is gently convex. The free margin of the episternal and hyposternal bones is acute, and with an internal thickening, as in *Cistudo*, *Testudo*, etc., forming a ridge, with abrupt inner face. This face extends backwards as a groove, to the axillary process of the hyosternal, forming a characteristic mark. Although the extremity of the episternal bone is lost, and the mesosternal exhibits no trace of the intergular scute, the outer sutures of the gular scuta are so far posterior, as to render it highly probable that the intergular plate existed. At the point where this suture reaches the margin, the latter is openly emarginate. The posterior suture of the humeral scute crosses the margin half way between the axilla and the episternal suture, and is not marked by a notch. The last named suture is transverse. On the xiphisternal bones the groove of the anterior suture of the anals is plainly visible. It is regularly convex forwards and in one specimen is double.

In a second specimen of about the same size, parts of two costal bones are preserved. They are thick, and display the usual costal and vertebral scute-sutures. The latter one in a groove, for the middle of the vertebrals is elevated, and the costals project shoulder-like just outside the groove.

In a third specimen a little larger, xiphisternals with several marginals are preserved. A free posterior marginal is regularly recurved, and the scute-sutures are deeply impressed. The marginal scuta have evidently been marked with concentric grooves within their margins. The first marginal bone of the bridge has a very obtuse edge.

In none of the specimens are the surfaces sculptured.

Measurements.

	No. 1. M.
Width plastron at axilla	0.086
Length plastron from axilla (approximate)	.05
Thickness hyosternal at mesosternal	.009
" " " hyposternal	.0065
Width mesosternal	.037
Length "	.026
Thickness of a vertebral	.006
" " xiphisternal (normal)	.004
" " " at pubis	.007
	No. 2.
Thickness costal at hump	.0075
Width of costal	.0175
	No. 3.
Width of posterior marginal	.027
Length " "	.019

The mesosternal, though found with No. 1, does not fit it exactly and does not belong to it.

NOTOMORPHA GRAVIS. Cope. species nova.

This species is known by portions of one, and probably of other specimens. The type is larger than any of the last described, and equalled some of the *Cheloniae* of the ocean in dimensions. The right hyosternal bone indicates both resemblance and difference from the *N. testudinea*. The former is seen in the internal thickening parallel to the margin, bounded behind by a deep groove extending to the axilla. A peculiarity, in which it differs from the *N. testudinea*, is seen in the posterior position of the humero-pectoral dermal suture, which originates at the axilla. The epi-hyosternal suture is concave. The thickened portion of the episternal margin is shorter and wider than in the species just named, the width being to the length as 2.5 to 2; in *N. testudinea*, as 1.5 to 2.

	M.
Thickness of hyosternal anteriorly	.011
Width of costal, (?) second specimen	.058

Surfaces not sculptured.

NOTOMORPHA GARMANII. Cope. spec. nova.

Represented by numerous fragments from a bluff, six miles north of the Bear River. There are numerous bones of the carapace and plastron. A characteristic piece is the episternal bone. It displays marked difference from the same element in the type of the genus, in lacking the acute edge and internal thickening. The margin is obtusely rounded and the suture with the hyosternal is convave. The anterior margin is truncate. The dermal sutural grooves are well marked. There is a large intergular scutum, which evidently encroached considerably on the mesosternal (a piece not preserved) and probably subtriangular in shape. The gulars are reduced to triangular areas on the outer anterior angles, the suture, with the humeral, being in front of the middle point between the angle and the hyosternal suture. The margin is less distinctly emarginate at this suture than in *N. testudinea*.

The marginal bones belong to both bridge and free edge. They are all much thickened medially, but with thin proximal sutural margins. The free ones are well recurved, and with regular, rather thickened margins. The bridge marginals have very obtuse margins. Their general massiveness is in contrast to the thinness of the costals of which there are numerous fragments. Portions of vertebral bones are intermediate in thickness. There is no thickening or ridge on each side of the vertebral scuta. The scutal grooves are everywhere well marked. The surface of the marginals and episternal is obsoletely rugose, somewhat as in some species of *Taphrosphys*, from the Cretaceous.

This species was about the size of *N. gravis*, and differs from it in the episternal bone, etc.

Measurements.	M.
Length of episternal (approximate)	0.04
" from posterior suture do. to gular scute	.02
Thickness episternal, behind	.011
Length of a marginal bone	.042
Width of same " "	.045
Thickness " " "	.015
Width of a bridge-marginal	.04
Thickness of a vertebral	.007

This species is dedicated to my assistant and friend, Prof. Saml. W. Garman, of Chicago, whose eye detected the fragments which teach its character.

At a future time it is hoped that a fuller account of the fauna of this lake basin, now enclosed between the Eastern and Western ranges of the Wahsatch Mountains, may be given.

ON THE TERTIARY COAL AND FOSSILS OF OSINO, NEVADA.

By Edward D. Cope.

(*Read before the American Philosophical Society, July* 19, 1872.)

The locality of the exposure of these coals is in the northeastern portion of Nevada, twenty-five miles northeast of Elko, on the Central Pacific Railroad. The outcrop is on the south side of the low mountain range, bounding Humboldt Valley on the north. The beds are exposed in a drift and adjacent cutting, and a shaft 200 feet in depth. The strata are argillaceous, and in some degree calcareous, and are very thinly laminated; so much so as to resemble thin brown or black paper in some portions of the series. They are highly carbonaceous, and burn freely; some of them with the odor of amber, which appears as a gloss on some of them. Descending sixty or more feet through these shales, we reach a bed of solid argillaceous material, of a dark green color. This can be removed with the pick, but hardens on exposure to the atmosphere. It contains fresh-water shells. The first bed of coal is two and a half feet in thickness, with one or two laminæ of slate. The second bed is twelve feet deeper, and is about three feet in thickness. In quality, both resemble cannel, but have more lustre.

Masses of the laminated shales resemble the *braun-kohle* of Bonn, Prussia, and they contain fossils disposed in the same way. These consist of multitudes of leaves, mostly of dicotyledonous plants; of molluscs, insects, and fishes; the last two often in a fine state of preservation. The molluscs present forms similar to *Planorbis*, *Vivipara*, etc. The insects are mostly Diptera, and some of them are Nematocera. The fishes are fresh-water forms, of which, perhaps, four species were procured. I have made an examination of two of these, and find them to represent both species and genera new to science. One of these is of interest, as furnishing the first evidence of the appearance of the *Catostomid* type, now so extended in North America; the other is allied to a genus which has been discovered in the Eocene shales of Green River.

The shales are considerably less indurated in general than those of Green River. They have been greatly disturbed by the elevation of the ranges bounding Humboldt Valley, as they dip nearly south, at an angle of forty-five degrees, at the mine.

The same shales are exposed in the ravines on the south side of the valley, dipping at one point where a drift has been run, at an angle of forty-five degrees to the northeast. They contain at this place plants and shells similar to those of the north range.

The descriptions of two of the species of fishes are appended, with remarks. Further investigation will, no doubt, determine the age of this series.

Extensive beds of a highly silicious amorphous rock appear near to these shales, one series being exposed in a nearly horizontal position in the valley, but little below the coal shales, and apparently occupying a higher horizon. They are filled with huge silicious concretions, and in many places assume the appearance of sandstone. Similar strata of sil-

icious rock cap the foot-hills of the range, forming their southern slopes with the southern dip, appearing to be nearly conformable to the shales. Their escarpments are to the northward, and the outcrops are fissured in every direction, the debris being scattered over the lower levels. On one of these rather elevated valleys I found abundant remains of the trunks of ancient forest trees, completely silicified. Many of the trunks must have measured five feet in diameter, and display the concentric laminæ of the dicotyledonous type. They were variously altered; some becoming chalcedony, and others opal; portions being black, red, yellow, purple, or white, of great purity.

At another outcrop of the silicious strata, a few miles distant from the above locality, the rock was found to be variegated by concentric bands of red, yellow, black, and white. Though fine in texture, it is not sufficiently translucent to constitute a valuable agate, which it otherwise resembles.

The connection between these silicious strata and the silicified wood seems apparent. The silica deposited in sufficient quantities to form strata of from twenty to forty feet in thickness, would suffice to impregnate submerged forests. That these strata are of sedimentary age is not settled, but they seem to be conformable to, and later than the tertiary shales just described.

TRICHOPHANES. Cope. Gen. nov.

Allied to *Erismatopterus*, Cope, and to the family of *Cyprinodontidæ*. Dorsal and anal fins short, each with a long and short spinous ray on the anterior margin. Ventrals beneath the dorsal. Operculum, with a longitudinal keel above. Mouth with wide gape, extending beyond orbit. Scales wanting, represented by rigid fringes or hair-like bodies.

Several important characters of this genus are not very distinctly displayed by the specimen described. This is especially the case with the maxillary region. The premaxillary bone evidently forms a large part of the arcade of the mouth, but whether the whole, is not certain. The presence of teeth, and number of branchiostegal radii, cannot be stated.

Other points, more definitely exhibited, are a preoperculum without serrations, directed a little obliquely backwards; a coracoid of little width; an inferior postclavicle with a superior (proximal) conchoidal expansion and long, slender shaft, extending to the anterior extremity of the femora. The latter are quite slender and acuminate anteriorly, and grooved to the apex, but apparently not furcate. They do not present any marked posterior union. Vertebræ not elongate.

Caudal fin furcate. Interneural spines wanting in front of dorsal fin; those of the anterior rays very strong. Interhæmals of the anterior anal rays similarly strong. Caudal fin embracing one vertebra, and supported by separated hæmal spines.

The characters which separate *Trichophanes* from *Erismatopterus*, are seen in the large mouth and short muzzle, and in the peculiar covering of the body. In the former character it resembles some of the *Scopeli*,

while the latter is not seen in any genus. The bristle-like bodies are scattered over the whole extent of the fish, excepting the head and the fins, and are arranged in little aggregations, which are irregularly disposed. The processes themselves lie irregularly together, as though free from each other, and are evidently not the impressions of keels of the scales. Traces of other scales are not visible, and the bodies described would suggest the existence of an ossified ctenoid fringe on a less fully calcified scale, or possibly without such basis.

TRICHOPHANES HIANS. Cope. Sp. nov.

Vertebræ, D. 9; C. 15; six between interneural spine of dorsal, and interhæmal of anal fin. Radii, D. II. (?) 6 (soft rays somewhat injured); A. II. 7; V. and P. not all preserved; caudal rays numerous, forming a deeply bifurcate fin. The ventrals reach a little over half way to the anal, and the latter about half way from its basis to that of the caudal fin. The dorsal fin, laid backwards, reaches the line of the base of the first anal ray. The first dorsal ray is a little nearer the end of the muzzle than the origin of the caudal fin. The muzzle is very obtuse, and if the specimen be not distorted, not longer than the diameter of the orbit. The gape extends at least to the posterior line of the orbit. The suborbital region deep posteriorly.

In its present somewhat distorted condition the specimen measures in

	M.
Total length	0.059
Head	.016
Vertebræ	.029
Caudal fin	.0142
Length dorsal spine	.008
" anal	.008
" of hair-like bodies	.0005

AMYZON. Cope. Genus novum Catostomidarum.

Allied to *Bubalichthys*. Dorsal fin elongate, with a few fulcral spines in front, and the anterior jointed rays osseous for a considerable part of the length. A few short osseous rays at front of anal fin. Scales cycloid. Caudal fin emarginate. Mouth rather large, terminal.

The characters of this genus appear to be those of the *Catostomidæ*. There are three broad branchiostegals. The vertebræ are short, and the hæmal spines of the caudal fin are distinct and rather narrow. In one specimen a pharyngeal bone is completely preserved. Not having it before me at the moment, I merely observe that it is slender, and with elongate inferior limb. The teeth are arranged comb-like, are truncate, and number about thirty to forty. This and other portions of the structure will be more fully described when the whole series of specimens is investigated. The bones bordering the mouth above are a little displaced, and the lower jaw projects beyond them, and is directed obliquely upwards. The dentary bone is slender and toothless, and the angular is

distinct. The premaxillary appears to extend beneath the whole length of the maxillary. Should this feature be substantiated, it will indicate a resemblance to Cyprinidæ. The maxillary has a high expansion of its superior margin, and then contracts towards its extremity. Above it two bones descend steeply from above, which may be out of position. The preoperculum is not serrate. The superior ribs are well developed.

This form approaches, in its anterior mouth, the true Cyprinidæ through *Bubalichthys*. It is the first extinct form of Catostomidæ found in this country.

AMYZON MENTALE. Cope. Species nova.

This fish occurs in considerable numbers in the Osino shales, and numerous specimens have been procured. Two only of these are before me at present. They are of nearly similar length, viz., M. O. .12 and .105. The most elevated portion of the dorsal outline is immediately in front of the dorsal fin. From this point the body contracts regularly to the caudal fin. The dorsal fin is long, and is elevated in front and concave in outline, the last rays being quite short. They terminate one half the length of the fin in front of the caudal fin. The interneural spines are stout in front and weak behind. Radii, III. 26, and (?) II. 23. There are about twenty-three vertebræ between the first interneural spine and the end of the series in the former specimen, in which, also, there are no distinct remains of scales. In the second, scales are preserved, but no trace of lateral line; there are six or seven longitudinal rows above the vertebral column. The anal fin is preserved somewhat damaged; the rays are not very long, and number II. 7. The anterior interhæmal is expanded into a keel anteriorly. Ventral fins injured.

The ribs and supplementaries are well developed. The inferior quadrate is a broad bone, with deep emargination for the symplectic. Depth No. 2 in front of dorsal fin, M .025. Length basis of dorsal, .026.

ON THE EXISTENCE OF DINOSAURIA IN THE TRANSITION BEDS OF WYOMING.

BY EDWARD D. COPE.

(*Read before the American Philosophical Society, Sept.* 19, 1872.)

During the present season, F. B. Meek, of Dr. F. V. Hayden's Geological Survey of the Territories, discovered some large bones near Black Buttes Station, on the Union Pacific Railroad, fifty-two miles east of Green River, and near the Hallville Coal Mines. Shortly afterwards I visited the spot with a branch expedition, and commenced excavations with a view to the recovery of the remainder of the animal. The position was discovered to be between the thinner or lower strata of the Bitter Creek series of coal, which at this point, occupy a position of elevation and crop out high on the bluffs. Two strata appear above the

sandstone in which the bones occur, and one below it. The portions of the skeleton found, rested in the midst of vegetable debris, as sticks and stems, and was covered with many beautiful dicotyledonous leaves, which filled the interstices between the bones. The plant-bed gradually passed into a shell-bed, containing numerous thin dimyaria, and close by, some oysters were found. The whole question as to geologic age and aqueous conditions during which these beds were deposited, being unsettled, I gave especial attention to the recovery of the bones, with the view of reaching a definite conclusion on these points.

We succeeded in recovering sixteen vertebræ, including a perfect sacrum, with dorsals and caudals; both iliac and other pelvic bones, those of one side nearly perfect; some bones of the limbs, ribs and other parts not determined.

The vertebræ are large. The dorsals are short, with vertically oval centra, and small neural canal. The diapophyses originate well above the neural canal, diverge upwards, and are triangular in section. The neural spine is very much elevated, and the arch short antero-posteriorly. The zygapophyses are close together in both directions, those of the same aspect being separated by a narrow keel only. They no not project, but consist of articular surfaces cut into the solid spine. The latter is flat and dilated distally. The articular faces are nearly plane with a slight median prominence.

The ribs have two articular surfaces, but I found no capitular pit on the dorsal centra.

Elevation of centrum, 7.5 in.; width of the same, 5 in. 7.5 lines; length of do. 3 in. 8.5 lines. Total elevation of a dorsal vertebra, twenty-eight inches three lines. The sacrum consists of five vertebræ, the anterior centrum not depressed. They give out huge diapophyses which are united by suture. They are themselves united distally in pairs, each pair supporting a longitudinal convex articular face for the ilium. Each pair encloses a perforation with the centra. The first diapophysis goes off from the point of junction of the first and second vertebræ, the second from the third only, and is more slender. The total length is 25 in.; and the width 30 in. Its vertebræ are flat below, with latero-inferior angles. The last centrum gives off a simple diapophysis.

Another vertebra exhibits a diapophysis as low as the floor of the neural canal and united by coarse suture. Others posterior to the sacrum are more elongate with slightly compressed centrum, and with diapophysis opposite floor of canal and not united by suture. Centra flat below; no chevron bones discoverable. Length centrum, 4 in. 4 lines; depth of articular face, 4 in.; width of do. 4 in. 3 lines.

The iliac bone is extended antero-posteriorly. One extremity is thick and rather obtuse, but of little depth. There is a large protuberance above the acetabular sinus. The other extremity is dilated into a flat thin plate of rather greater length than the stouter extremity. From

one of its margins, a rod-like element projects. Its total length is about four feet, of which the acetabular sinus measures about 8.10 inches.

A short bone pertaining to the limbs has the articular surfaces at a strong angle to each other, hence the shaft is twisted. It is deeply grooved on one side near the extremity. The other extremity bears a rather flattened hour-glass shaped articular face, and below it on one angle is a crest. The convexity of the surface is not great, and this extremity resembles that of a Dinosaurian or Crocodilian reptile. Its length is, however, only eight and a quarter inches; apparently too small for a humerus, though this is not certain, while it is decidedly too small for a metatarsal of such an animal.

From the above description, it is evident that the animal of Black Buttes is a Dinosauran reptile, the characters of the sacral and iliac bones alone sufficing to demonstrate this point. If the reader will compare the measurements given for species of this group already known, he will observe that those of the present animal exceed those yet described from North America. It is possible that if the corresponding parts of *Hadrosaurus tripos*, Cope, or *Thespesius occidentalis*, Leidy, are discovered, they may approach it.

It is thus conclusively proven that the coal strata of the Bitter Creek Basin of Wyoming Territory, which embraces the greater area yet discovered, were deposited during the Cretaceous period, and not during the Tertiary, though not long preceding the latter. It appears that the forests that intervened between the swamps of epochs, during which the coal was formed, were inhabited by these huge monsters. That one of them laid down to die near the shore of probably a brackish-water inlet, and was soon covered by the thickly fallen leaves of the wood. That continued subsidence of the level submerged the bones, which were then covered by sand.

The form of the ilium differs very materially from that of *Hadrosaurus*, and the vertebræ are plane, thus differing from *Thespesius*. The limb bone is distinct from anything in *Lælaps*, which, moreover, probably resembles *Thegalosaurus* in its ilium. The present form recalls rather *Cetiosaurus*. As it is evidently new to our system, it may be called AGATHAUMAS SYLVESTRIS.

NOTICES OF NEW VERTEBRATA FROM THE UPPER WATERS OF BITTER CREEK, WYOMING TERRITORY.

BY EDWARD D. COPE.

(*Read before the American Philosophical Society, September* 19, 1872.)

SYNOPLOTHERIUM CANIUS. Cope. Gen. et sp. nov.

This genus possesses the dental formula so far as known, $I.\frac{3}{3}c.\frac{1}{1}M.\frac{?}{6}$. In the only specimen with molars, the crowns are much worn, but in all, the antero-posterior much exceeds the transverse diameter, and consisted

of two lobes. The posterior molar had no more lobes, and is smaller than the penultimate. The first is two-rooted, and is separated by a wide space from the inferior canine. The superior canine is of disproportionately large size, and issues a little behind the premaxillary suture. The incisions are crowded closely together, and are of conic form. The exterior is several times as large as the others. The inferior incisors are of huge size, project upwards after the manner of rodents, and are inserted by a short base into the solid symphysis. They are separated by a short interspace, which is without alveoli.

The fore foot possesses four digits, of which the inner is considerably the shorter. Phalanges not slender; ungueals flat, deeply fissured above. Caudal vertebræ slender.

This most remarkable genus is not at present referable to its proper order. The superior anterior teeth are of carnivorous type; the opposing teeth look like those of rodents, while the molar teeth differ from both. It is allied to *Anchippodus*, Leidy, which is only known from mandibles. This form Dr. Leidy has called the "gnawing hog," but, as it probably exhibits a structure similar to that seen in the present genus, it is obvious that the huge symphyseal teeth were not designed for gnawing in the usual sense. I suspect these animals to have lived largely on turtles,* and that the structure in question was adapted for crushing their shells. This is the more likely from the prodigious number of turtles which must have existed contemporaneously with them. There are twenty species described from the Bridger formation, and their numbers are legion, as already described by Professor Marsh. Their bones are always in sight, and six or eight are not unfrequently found lying together.

Char. specif. The mandibular rami, posterior to the symphysis, are not heavily constructed. The symphyseal teeth are very stout, and exhibit two longitudinal grooves on the outer and outer inferior face; the shaft is compressed, and the worn surface is on the outer side, as produced by the canines, and on the extremity, produced by the outer incisor. The superior canine is compressed, and as large as that of a grizzly bear. The outer incisor is nearly straight, and with conic crown. A large part of its shaft is exposed at the bottom of a wide vertical groove, which extends upwards between the canine tooth and a ridge descending from the edge of the nares. The external nareal opening is entirely anterior, and is narrowed below, in accordance with the narrowing of the premaxillaries.

	M.
Length of interior dental series to bases of symphyseal tooth	0.170
Depth ramus at last molar	.050
Length symphysis	.060
" muzzle from canine	.017
Length symphyseal tooth projected	.010
Diameter " " "	.026
" canine " "	.023

* This view was already expressed in *The Friend*, Philada., 1872, Winter

If the body of this animal were of usual proportions as relates to the skull, it was about the size of the black bear (*Ursus americanus*). The worn condition of the teeth indicates an old animal, and one that had lived on hard food.

EOBASILEUS CORNUTUS. Cope.

Gen. et sp. nov.

Established on remains of five individuals of the average size of the *Mastodon ohioticus*. These indicate clearly a form of proboscidian not before recognized. The structure of the tibia and astragalus, clearly indicate that the species is not artiodactyle, while the perfectly simple femur is not perissodactyle. The posterior part of the cranium, and the short stout phalanges are proboscidian. The existence of horns on the frontal bones separates it at once from *Dinotherium*, *Mastodon*, *Stegodon*, or *Elephas*, and indicates a remarkable combination of structure not before known to naturalists. The gigantic size of the typical species adds to its interest, and shows it to have been the monarch of the remarkable fauna disclosed by recent researches in Wyoming.

The distal extremities of both humerus and femur are flat, the former with oblique trochlear face and shallow olecranar fossa. The great trochanter of the femur is flat and not recurved; little trochanter wanting. Spine of tibia very obtuse; distal extremity little excavated. Distal extremity of phalanges not divided by trochlear ridge.

Articular extremities of vertebræ plane; the cervicals very short.

Cranium with vertical occiput with broad convex superior outline. Temporal fossæ lateral, posteriorly small. Horn-cores obtuse, compressed, most at base; direction divergent.

NUMBER 1.	M.
Length of horn-cores (6 inches)	0.152
Elevation occiput from foramen magnum	.180
Width across supra-occipital crest	.315
" of condyles with foramen	.206
" " paramastoid process	.087
NUMBER 2.	
Transverse diameter condyles humerus	.185
NUMBER 3.	
Diameter extremity tibia (transverse)	.126
" " " (antero-posterior)	.096
" head " (transverse)	.140
" glenoid cavity scapula	.150

Further details of the structure of this animal will be sought for with interest. From the manner of its occurrence, it probably went in families or herds.

CROCODILUS CLAVIS. Cope.

This is a large species with a muzzle of narrowed proportions and sufficient depth to give it a broad oval section. The nasal bones appear to have reached the nareal orifice. The anterior superior teeth are very large, especially the canine. The inferior tooth corresponding is large,

and occupies an emargination which approaches near to the nasal suture. The pitting of the muzzle is fine, and the swollen interspaces much the wider. The teeth have stout conic crowns, with well-developed cutting edges and coarse striate sculpture. The mandible is acuminate to the narrow extremity, and has a long symphysis, which extends to opposite the third tooth behind the notch. The cervical vertebræ preserved, have round cups; they have a simple elongate hypapophysis with a pit behind it; shoulder very prominent.

	M.
Length of ramus with teeth	
" " symphysis	.135
Width do. at end of symphysis	.085
" do. " mandible	.020
" maxillary at third tooth above	.060
" " " notch above	.020

This species has a more slender muzzle than those described by Marsh and Leidy, and is of larger size.

RHINEASTES PELTATUS. Cope.

Gen. et sp. nov. Nematognathorum.

Established on cranial and other bones, with spines of a siluriform fish of the size of the largest species of *Amiurus*. The form, in the excessive rugosity of the external long surfaces, reminds one of some of the Brazilian *Dorades*. The frontal fontanelle is closed, though very distinctly marked by a groove of the surface not rugose. The rugosity consists of innumerable, packed osseous papillæ. The cranial ossification is continued posteriorly as a shield, which is strongly convex from side to side. The spine is symmetrical, and probably dorsal. It is compressed and curved antero-posteriorly, and is deeply grooved behind. Laterally it is closely striate grooved; the anterior face is narrowed, obtuse, and minutely serrate with cross ridges; each side of it is rugose with several irregular series of pronounced tubercles, arranged transversely.

	M.
Width frontal bone near front of fontanelle	0.012
Thickness at do.	.004
" " of casque	.004
Width spine	.005
Depth "	.009

RHINEASTES SMITHII. Cope.

Indicated by a dorsal spine of an individual of smaller size than the type of the last named. It is less rugose, and more firmly striate, and possesses a row of short reverted spines in its posterior groove. The anterior edge is furnished with a finely serrate keel, which has a groove on each side at the base. The section is oval, the posterior face not being flattened as in the last species. Antero-posterior diameter near middle M. .005; at base .006; width behind above base .006.

Named for my respected friend, Daniel B. Smith, of Germantown; many years Principal of Haverford College, and a student and lover of the Natural Sciences.

SECOND NOTICE OF EXTINCT VERTEBRATES FROM BITTER CREEK, WYOMING.

By Edward D. Cope.

(*Read before the American Philosophical Society, Sept.* 19, 1872.)

Palæosyops vallidens. Cope. Sp. nov.

Represented by the dentition of one maxillary bone with other bones of one individual; a portion of the same dentition of a second; with both rami of the mandible with complete dentition of a third. The species is distinguished by the details of the dental structure, and by the superior size. It exceeds, in this respect, the *Palæosyops major*, Leidy; while the three posterior lower molars measure 4.5 inches in length, the same teeth of the present animal measure 5.25 inches. The last superior molar of another specimen measures 2 inches in length; in the third the first true molar is 1.5 inch in length, while the last inferior molar is 2.25 inches long. The peculiarity in the structure of the superior molars consists in the existence of two strong transverse ridges, which connect the inner tubercle with the outer crescents, enclosing a pit between them. These are most marked on the premolars, where also is found the peculiarity of the almost entire fusion of the outer crescents into a single ridge. These united crescents are narrower than in *P. major*, and the summits of all the crescents are relatively more elevated. The number of inner tubercles is the same as in that species; all the teeth have very strong basal cingula, which rise up on the inner tubercle. The last inferior molar is relatively narrower than in *P. major*, and the posterior tubercle is larger and longer, and is an elevated cone.

This species is, after those next described, the largest mammal of the Wyoming Eocene.

Loxolophodon. Cope.

(Proceed. Amer. Philos. Soc., Feb. 16, 1872.)

The discovery of the remains of numerous animals of this genus, confirm the propriety of its separation from *Bathmodon*. The characters are as follows:

Type of extremities Proboscidian. Femur without third trochanter, toes short, stout. Dentition: I. 1; C. 0; P. M. 4; M. 3. The premaxillary is at the posterior margin of that bone, and is a large recurved trenchant tusk. There is a long edentulous interval between it and the first premolar, which is smaller than the others. These support an outer crescent and a small inner tubercle. In the anterior premolars, the crescent is nearly straight, in the posterior more curved. With use, the crescent and tubercle wear together and form a short lance-head surface. The crescent is angular, and occupies the whole crown in the molars, and the tubercle is small and not symmetrically placed. The teeth on the maxillary bone are remarkably small for the size of the animal. Lower jaw not observed.

The cranium presents a remarkable appearance on account of the pro-

longation of the muzzle. In front of the zygomatic arches, the form is compressed and roof-like above. Above the tusks the nasals expand, and are produced to a great distance, terminating in osseous prominences. The premaxillaries are also much produced; their anterior part is slender and toothless, and does not extend so far as the nasals.

The orbit is not inclosed behind, and has no marked superciliary or other margin. Above it, on each side, a horn-core is given off, the pair diverging from approximated bases. Occiput vertical.

The affinities of this genus are not close to any known, excepting *Bathmodon*. This has the six premaxillaries of nsual proportions, at least three true molars, and the posterior premolars with three crescents. The general relationships are proboscidian, and associated in some measure with *Synoplotherium*, *Auchippodus* and *Pseudotomus*.

Besides the *L. semicinctus*, Cope, originally described, the researches under Prof. Hayden's Geological Survey, have determined the existence of two or three other species of much larger size.

LOXOLOPHODON CORNUTUS. Cope.

Eobasilus cornutus. Cope.

Established on portions of several skeletons, including one with femur, pelvis, scapula, vertebræ and cranium. The latter measures about thirty-four inches in length. The horn-cores are very stout and sub-triangular in section at base and with a rudimental knob on the inner side; height seven inches about. A massive protuberance of a recurved lobate outline rises on the anterior margins of the nasal bones on each side. They meet, leaving an emargination in front, giving the nasal bones a bi-lobed outline. The iliac bones are very wide, the expanse of both together being fifty-four inches. The centrum of a sacral vertebra is four inches in diameter.

LOXOLOPHODON FURCATUS. Cope.

This species is indicated by portions of the nasal bones. These have differed in form materially from those of the *L. cornutus*. The convex protuberances seen in *L. cornutus* were here represented by processes of singular form. They were compressed, narrowed at the base, and expanded distally into a flat spatulate body. The whole process measures seven to eight inches in length, and three and a-half in width distally. The animal could not have been materially smaller than the *L. cornutus*.

LOXOLOPHODON PRESSICORNIS. Cope.

Established on numerous remains, including horn-cores of species similar in size to the last. Its marked peculiarity, as first noticed, consists in the compression of the horn-cores throughout the proximal half of their length, with their more acuminate form, than in *L. cornutus*. They measure also about seven inches in length.

The affinities of these remarkable animals will be shortly discussed.

They were the gigantic mammals of our Eocene period, representing the Elephants and Mastodons of the Miocene, which they equalled in size.

The Geological Structure of Tazewell, Russell and Wise Counties, in Virginia.

By. J. P. Lesley.

(*Read before the American Philosophical Society, April 21st*, 1871.)

I was called upon recently to examine a part of the Alleghany Mountain Range, between the New River (Kanawha) in Middle Virginia and the north line of the State of Tennessee, for the purpose of determining the nearest possible approach to a workable coal region of a contemplated Railway from Harper's Ferry on the Potomac to Knoxville in Tennessee.

The geological structure of this part of the United States is so peculiar and so nearly unknown to geologists, or at least unnoticed in any published memoirs, that I have taken some pains to portray it, believing that it will be an acceptable contribution to the literature of the science and to the proceedings of this Society. The present paper is, however, a virtual continuation of my description of the South Virginia Coal region of Montgomery and Wythe Counties, read before this Society in 1862, and published in Vol. IX of its Proceedings, pages 30 to 38.

Professor William B. Rogers, State Geologist of Virginia, is well acquainted, no doubt, with the essential facts about to be described, and probably has materials for a more extensive description of the central belt of the Appalachians among the unpublished archives of the State Geological Survey of Virginia; but I doubt that any sections have been constructed which express more clearly the state of things in a geological sense, than those which I have this opportunity of making known.

Professor James M. Safford, State Geologist of Tennessee, has studied the Southern continuation of the belt, and describes it in his Geology of Tennessee, Nashville, 1869. But the sections given in that valuable work, which has cost its author so much time, skill and labor to prepare, and for which American Geologists are most grateful, are only adapted for general description, not being drawn to a natural scale, and are not of use for the critical study of the dynamic problem here offered to the consideration of structural geologists.

The map which accompanies this paper was made to show the railway avenues through the region above named, by bringing out clearly its main *topographical* features. I have colored it to show to the eye its main *geological* features, especially those due to the lines of Downthrow, which are also the lines of limit for the Coal Measures. I have confined the coloring within narrow limits so as not to obscure the prime facts. No distinction is made therefore between the Calciferous, Trenton, Birdseye, Black River and Hudson River formations, all of them being colored

blue, representing the *limestone valley formations*, Lower Silurian, Nos. II and III of the Pennsylvania nomenclature.

The Oneida Conglomerate, Shawngunk Grit, and Medina Sandstone, Middle Silurian, No. IV, are left uncolored, to make their mountain character more conspicuous. The Upper Silurian, Clinton, No. V, carrying the Dyestone, Fossil Iron Ore, is colored red, to catch the eye, because of its practical importance for railway purposes, and because it is the red formation of the North, *par excellence*, although it is not so marked in nature along its southern outcrops. If the native coloring of the soil were to govern the tinting of the map the Hudson River slates (No. III) would require this pigment.

The Devonians are represented by a Vandyke brown wash (Nos. VIII, IX, X), and the Coal Measures by a wash of Payne's gray. No color is allowed for No. XI., which shows so prominently on the geological map of Pennsylvania in red, because its outcrop is feeble here and *not* especially red.

The main features of the topography are quite correct (except near its eastern end, of which I can say nothing); and it distinctly shows how the mountains are made, by the downthrows, to run in pairs, with a "poor valley" between each pair, consisting of Devonian Sandstones and Upper Silurian shales containing the Clinton, Dyestone, or Fossil Iron Ore; and how the pairs are separated by wider Lower Silurian limestone or "rich" valleys, containing the villages and farms of blue grass and scattered and probably extensive deposits of Brown Hematite Iron Ore, which I have *not* colored.

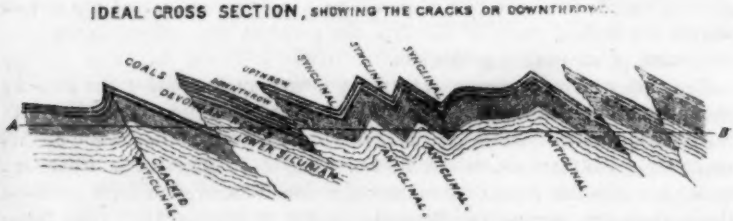
The black lines 1, 2, 3, 4, &c., show where the vertical geological sections in this report are to be looked for on the map.

There is no map of this country worthy of the name. I have copied the State map and then changed its details according to my observations. The geology is perfectly simple, when one has the key to it. The key to it is given by the pairing off of the mountains along the Downthrows.

I begin then with this curious and all important phenomenon. Fig. 1, shows it in a *purely ideal* way; but reference must be made to Sections 1, 2, 3, 4, &c., for its *actual* representation in different places.

Fig 1.

IDEAL CROSS SECTION, SHOWING THE CRACKS OR DOWNTHROWS.



What the power was, which cracked the anticlinal and synclinal curves,

and shoved the 10,000 feet of Carboniferous, Devonian, and Silurian Formations over each other, like cakes of ice in a river freshet, it would be premature here to discuss.

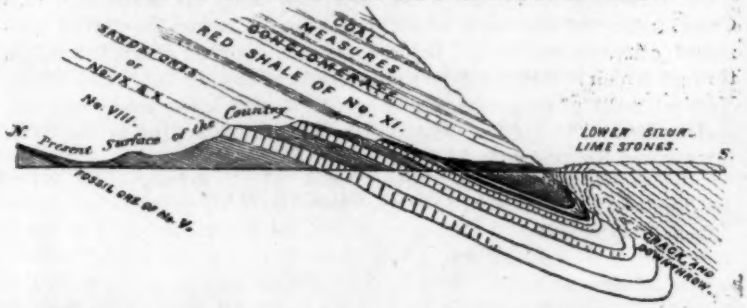
The consequence has been, that along the straight lines of these cracks —lines running for fifty or a hundred miles,—the coals at the top of the system abut against the limestones near its bottom.

Another consequence has been that no coal is to be found but on the north side of each crack. The whole mass of rocks above the line A—B has been removed (it is needless to describe the process, which is still going on and can be studied by any observer), so that the vast coal field which once covered this country is no longer in existence; and the only remnants of it left are long stripes, a few hundred *yards* wide, running along the north lip of each crack.

A third, and equally important consequence, has been, that even this poor remnant of the Coal-Measures, where it is left, consists of only the very lowest bed or the two lowest beds of the Coal Measures, the poorest of all the coal beds of the system. Fig. 2 will show how this result occurs:

Fig. 2.

SHOWING THE COAL BEDS LEFT IN THE DOWNTHROW



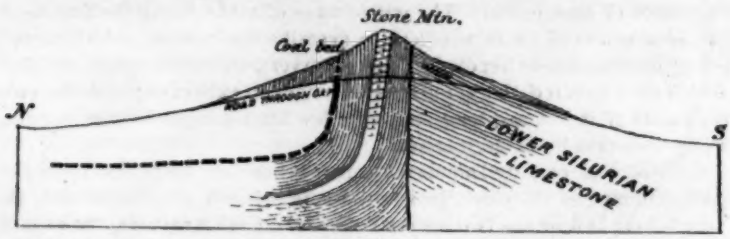
It is not until, going north 30° west, several such downthrows with their comparatively worthless coal fields (so to call them) have been passed, that the real coal field of the country is reached. Its southern edge runs along a straight downthrow lying just north of the Clinch River.

I shall first take up this line at Guest's River, in Wise County, and follow it northeastward, ascending Clinch River; and I will give sections of its Coal Measures, wherever I studied them.

Stone Mountain, which is the south border of the Guest River Coal Fields, in Wise County, is cut throughby Powell's River at the Big Gap Some miles further east its summit is notched by a wind-gap (Little Gap), through which the turnpike from Wise County Court House (Gladesville) to Scott County Court House (Estillville) passes. The *lowest coal bed* is opened on the side of the road a quarter of a mile before

reaching the gap; that is, high up the southern face of the mountain. The coal bed is 4 feet thick, and vertical. The core of the mountain is a vertical Conglomerate Sandrock. On the south face of the mountain are cliffs of Lower Silurian limestone. A fault, therefore, runs through the mountain lengthwise, thus:

No. 1 SECTION LINE ON THE MAP.

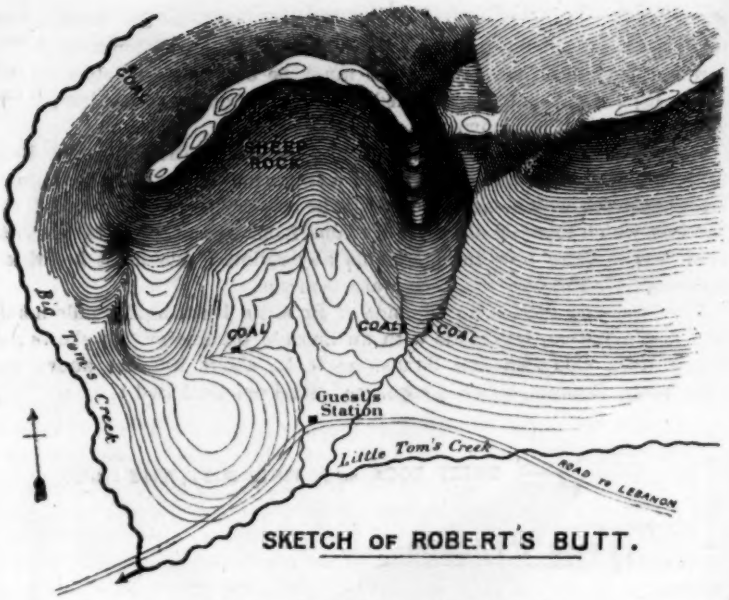


This section, however, I did not myself see; but the information from which I construct it was given to me so clearly, and agrees so exactly with what I saw myself further east, that I have no hesitation in assigning it a place in this report, without endorsing it more specially.

On the west side of Guest River, two miles below the mouth of Tom's Creek, a *two-foot coal bed* is mined; it lies nearly flat, under cliffs of horizontal conglomerate rock. Below this place, the river enters the cañon, through which it rushes for two miles before entering the Clinch River. Vertical walls of conglomerate, hundreds of feet high, stand opposite each other. This is the natural gate for a railway line to the Wise County and Kentucky Coal Field.

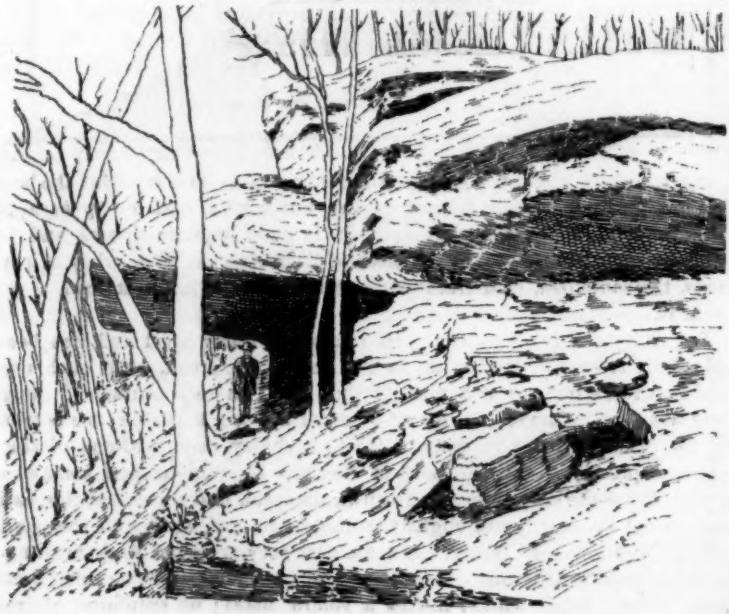
SECTION 2 ON THE MAP.

Coal beds are opened up and down Tom's Creek and its branches. One coal bed, from 5 to 6 feet thick, runs through the bases of all the hills, nearly at water level, and almost horizontal. It is mined for family use in the gulches back of Guest's Station (an old log fort, now a store and, although half a mile from the mouth of Tom's Creek, overflowed whenever Guest River is in high freshet), and by Mr. Jessee, and for several miles still higher up Tom's Creek. It is mined up Little Tom's Creek, and on Crab Orchard Creek, as a fine six (6) foot bed of rather handsome flaming coal, solid enough to wagon over rough roads, and not making much ashes or clinker in the grate. It is at least equal to



SKETCH OF ROBERT'S BUTT.

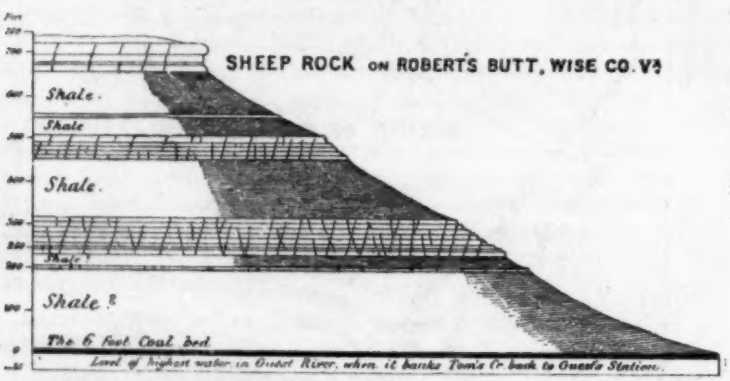
The Great Sheep Rock on Robert's Butt



the general run of the Lower Coal Measure coals in the Bituminous Coal Basins of the Susquehanna West Branch and the Conemaugh. I saw no other beds here; but there must be others both below it and above it; for the beforementioned two-foot bed ought to be above it, as the above section (2) shows.

I made a measured section of one of these hills, called Robert's Butt (over 700 feet high, and capped with a fragment of the great conglomerate sandrock which once covered all the country), as a specimen of the barriers which separate all these streams from one another, in the coal field, and to show how impracticable any railroad line must be which does not follow closely the great water-courses.

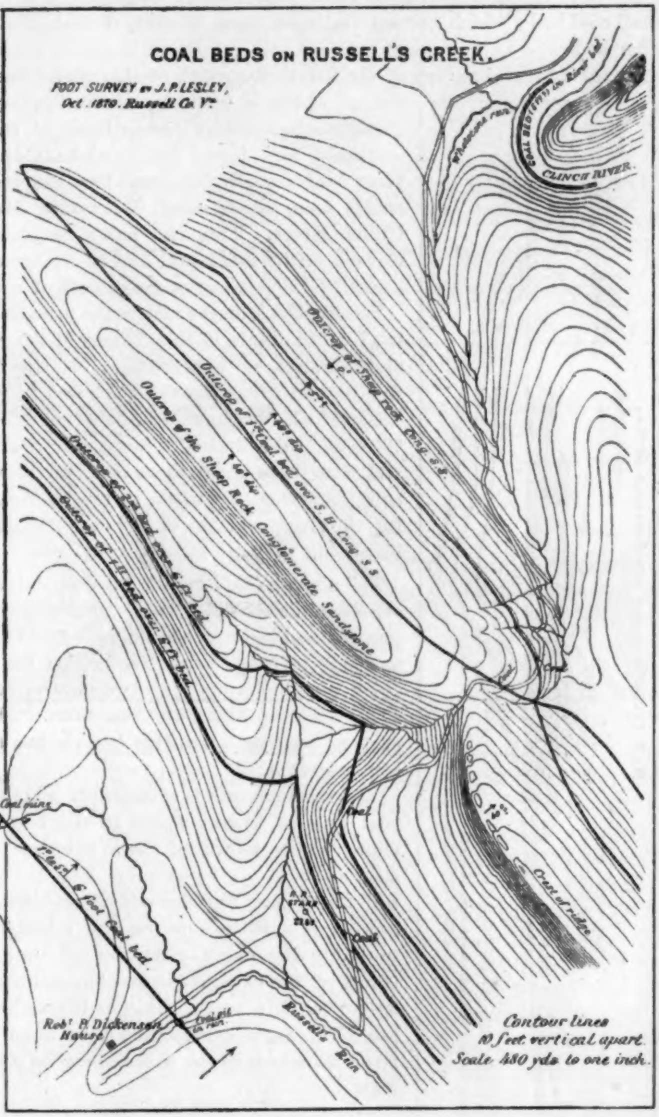
The following section up the side of Robert's Butt, half a mile north of Guest's Station, was made with an aneroid barometer. It shows the Sheep Rock Conglomerate Sandstone to be about 700 feet above the (Newberry, Robinet, Grier, Jessee, &c.) Six-Foot Coal Bed:


SHEEP ROCK on ROBERT'S BUTT, WISE CO. Va
Shale.
Shale
Shale.
Shale.
Shale.
The 6 foot Coal bed
Level of highest water in Guest River, when it banks Penn's Cr. back to Guest's Station.

At one place where the bed has been dug a little into, it yields the best kind of bituminous coal, fat and caking, but friable, with no appearance of sulphur, and making no clinker. It is good blacksmith-coal, and no doubt will make good coke. A piece of ill-made coke from what is, perhaps, the same bed, near Gladesville, shows that the best coke can be got from it.

On *Russe's Creek* this coal bed is also at water level and has been mined by Robert P. Dickenson in the bed of the creek, near his house, and in a run a quarter of a mile further east, where a horizontal gangway has been commenced. About 5 feet of the coal is visible; the bottom is not reached, being in water. Roof: a shaley clay, without distinct plant impressions. Upper part of the bed bituminous, and somewhat bony. From the first 12 inches downwards, solid, and somewhat like cannel. Coal in some parts slightly granular, reminding one of the sand-coal of Montgomery County. Bottom coal very good for blacksmithing; makes a hollow fire; but cakes little and goes out before morning; not much ashes; ashes white; makes a yellow blaze; no sulphuret of iron visible; no fossil leaves. Streaks of coal through the bed showing

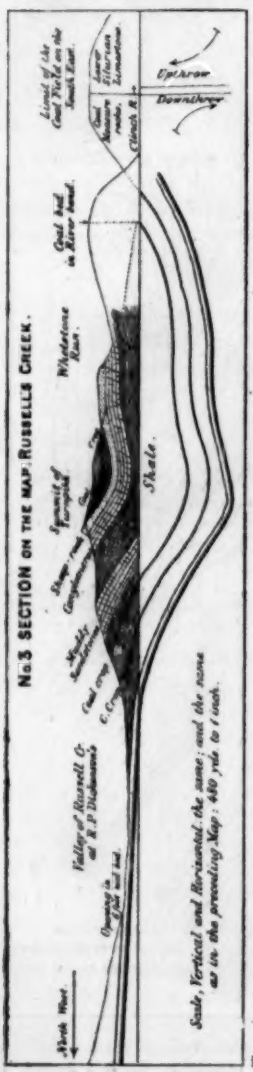
numerous minute discs of sulphuret of iron in the fissures; so that an analysis of the bed as a whole will give a notable percentage of sul-



phur; and it will be extremely difficult to pick the coal, if mined extensively, so as to furnish it free of sulphur. It is, however, on the whole, a satisfactory bed; and its harder benches will bear carriage well.

The bed dips at least 5° southward at this precise place; but not so much over a larger area. Over it are thin slabs of shaley sandstone, with large calamites and stigmaria stem impressions; and over these again a small coal bed; which cannot lie more than 20 feet, if that, above the other bed.

I made a careful survey of the hill to the south of this place, the summit of which is made by south-dipping conglomerate sandrocks (Sheep Rock of the last section); and found two coal beds outcropping on its north face, and two more on its south face, descending Whetstone Run to Clinch River. This run has a conglomerate terrace on its left bank, and is rendered very rocky by the descent of fragments of rock.


No. 3 SECTION ON THE MAP. RUSSELL'S CREEK.
Upthrow
Downthrow
Coal bed in River bank.
Whetstone Run.
Shale.
Valley of Russell Cr. at R. P. Dickenson's
Scale, Vertical and Horizontal, the same; and the same as in the preceding Map; 440 yds. to 1 inch.

Section No. 3 on the map is the most instructive I could obtain in this district of the region, and requires no explanation. It shows that the distance from the Six-Foot Bed up to the Sheep Rock Conglomerate is everywhere about 700 feet, and contains at least two coal beds; and that there is one more coal bed above the conglomerate. I had no means of determining the size or quality of any one of these three beds; but they are all, probably, under 3 feet.

The above sketch-map and this accompanying cross-section (No. 3) were measured on the ground and drawn to scale. They enable me to speak of only *one* coal bed above the Sheep Rock Conglomerate, with two outcrops on this road, looking like two coal beds. Further east, as will be seen, this bed (?) has several others over it.

The section renders it doubtful whether the coal dug at lowest water in the bed of the Clinch at the mouth of the Whetstone be the six-foot bed. It looks more like the second bed above it. But the southeast end of the section is a little obscure, and I had no time to study the exact character of the Downthrow of the Coal Measures against the limestones* at this point. It runs through an isolated hill, quite surrounded by a bend of the river, as shown in the sketch-map on the next page.

* Query.—Do these belong to an outcrop of the subcarboniferous limestone issuing from the fault?

The map below will give a better idea than any verbal description of the difficult nature of the ground for railroading purposes down Clinch Valley. The hills are from 200 to 300 feet high and present bold and massive cliffs of Lower Silurian limestone to the river.

It will also illustrate the general law that the principal rivers and large streams of this region of Virginia run in the lower members of the Lower Silurian limestone system, as they habitually do elsewhere, near the edge of the Freestone Carboniferous land. The cause of this is evident. The surface of the country as it is at present has been produced by the removal of all the geological formations above that which now forms the surface. When the Downthrows were first formed the drainage of the

SKETCH MAP OF CLINCH RIVER,
where it strikes the Coal Measures and rebounds, at Lick Run.

country was down the face of the Coal Measures to the crack and then along the crack sideways. This produced a very slow erosion of the Coal Measures, because of their numerous massive bed of sandstone. But the drainage along the cracks produced great erosion into the face of the sandy and magnesian limestone exposed by it. The drainage from above also produced caverns in the limestone. Out of these caverns issued streams which swelled the rivers which ran along the cracks. The formations over the limestone were worn rapidly away. The face of the limestone wall of the crack was worn back. And so, by the time the present surface level was reached, the rivers, which originally flowed on the Coal Measure side of the cracks, had got their valley-beds fairly established on the limestone side of the cracks; and, sometimes, at a considerable distance on that side.

As the lower limestones are massive and very soluble all the streams of the region which flow through them have extremely rough and tortu-

ous valleys, walled in at intervals with cliffs. The smaller streams head up in smooth valleys (of the upper limestones and slates of the Lower Silurian system) admirably fitted for railroad locations. But near their mouths, where they cut rapidly down through the lower limestones to flow into the cross streams, their beds are full of jagged rocks and their valleys difficult for cheap railroading.

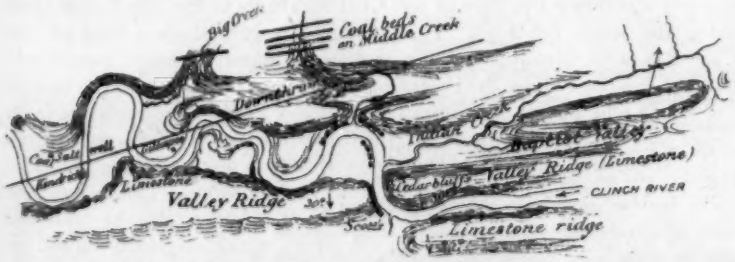
It is among these lower limestones that the beds of *brown hematic iron ore* lie. For instance, the cliff at the river bank, just where the road from the west along the north bank comes to the ford at the mouth of Lick Run, is a mass of sandy limestone, near the bottom of the Lower Silurian system. Further up the north bank of the river, east of Lick Run, is a long limestone hill on which many pieces of the ore are scattered, some of them very large. There is a good chance here for the existence of a valuable iron-ore deposit on a large scale. The ore is good.

THE COAL FURTHER EAST.

I made no detailed examination above Lick Run for a good many miles; and I have mentioned in a Summary Report the streams crossed by the coal beds in this interval. I will only add here, that some of these beds were *reported* to me as ten (10) feet thick. The six-foot bed may become thicker at points which I did not visit than it is where I saw it.

The "Mouth of Indian" is a thriving little village on the north bank of the Clinch where it enters Russell County. I surveyed this neighborhood carefully, because the coal beds here have been opened more extensively than elsewhere; because they stand at a higher angle and give a series; and because the downthrow is exhibited in a most curious and instructive manner. The river breaks through limestone just above Indian Creek mouth, forming bluffs called the Cedar Bluffs. A dam was built here forty years ago out of red cedar logs which has never needed repairs. It is fifteen feet high and backs the water two miles. Middle Creek descends from the north and enters just below Indian Creek.

Up Middle Creek are the coal mines. See the following map:



Two miles further down the river, Big Creek runs across the upper end of the wide and fertile bottom called the "Rich Lands," at the farm of Mr. Gillespie.

Two miles further west, a salt well, 354 feet deep, was sunk at the north edge of the river bottom, on Mr. Kendrick's land, twenty-two (22) years ago, and, at 337 feet, went through 6.7 (six feet seven inches) of

coal. Six feet at the top of the well was mud. All the rest was "sandrock," without coal.

Petroleum.—There was enough oil to grease the rods. The well was plugged up. Recently the plug was knocked out, when *fresh* water spouted from the 3½-inch hole to a height of three feet, but soon subsided. A film of oil stands on the water, which is very cold and too brackish to taste perfectly good, although cattle go to it in preference to drinking other water.

Salt.—The spot selected for the well had been a famous deer and buffalo lick. The ground had been eaten away by the animals. Thirty or forty deer used to be seen at one time at this lick; and spoonfuls of salt could be collected. It must be borne in mind that the salt wells of Eastern Kentucky get their water from the conglomerate at the base of the Coal Measures. There must, therefore, be a saltwater-bearing formation several hundred feet below the coal bed at the bottom of this well; supposing, 1, that it is the Six-foot Bed of Wise County; and supposing, 2, that the Sheep Rock Conglomerate Sandstone is *not* the true Conglomerate Base of the Coal Measures. But even if the latter supposition be wrong, and the Six-foot Bed be one of the Sub-Conglomerate Coal Beds of Eastern Kentucky, which is quite a possible thing, there remains a still lower "Knobstone," or Devonian Saltwater-bearing Formation, from which the salt water must find its way to the surface through the Great Downthrow and cross-fissures connected with it. This Devonian Saltwater-bearing Formation is that which supplies our deep salt wells in Western Pennsylvania, and is also the same as the Petroleum-bearing Formation of Venango County.

THE COALS AT MOUTH OF INDIAN.

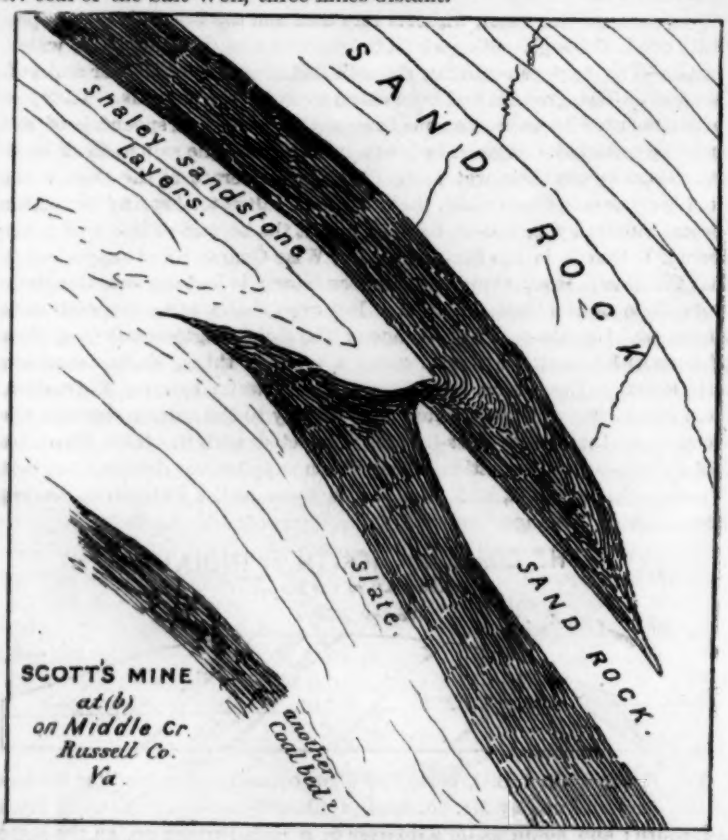
(Section No. 6 of the Map.)

The Six-foot Coal Bed, here, has been opened and mined for the use of the neighborhood by Mr. Scott, at (*a*) about 1½ miles up the creek from its mouth; and again at (*b*) a quarter of a mile further up, on the same south dip. At both (*a* and *b*) it shows a disturbance represented in diagram on the next pages.

The bed is here, really, but 2½ to 3 feet thick. It is covered with a plate of sandstone which is several feet thick; and, although the pressure produced by the Great Downthrow, which runs along at a distance of about half a mile due south of the locality of the mine, has folded the coal bed *with* the sandrock back upon itself, yet the sandstone of the rock, thus caught in between the walls of the fold of the coal, is perfectly solid and does not show the slightest trace of disturbance. This is a striking, but well-known phenomenon. The coal itself is bent round, and shows sharp tongues, in the fold.

At (*b*) the same sandrock is equally folded and unbroken, as the following diagram (looking in the opposite direction, *i. e.* east) will explain.

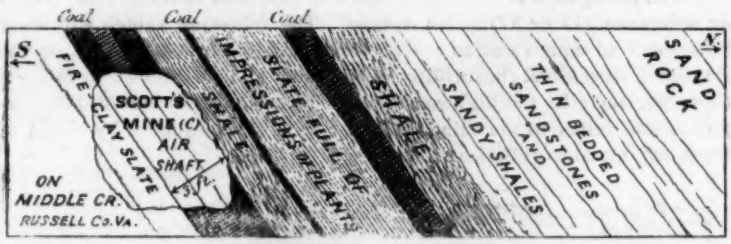
Here, also, the bed, which when doubled measures 5 or 6 feet thick, is really but a three-foot bed. There is nothing, in fact, to identify it with the "Six-foot" coal of Wise County. But it may very well be the 6.7 coal of the Salt Well, three miles distant.



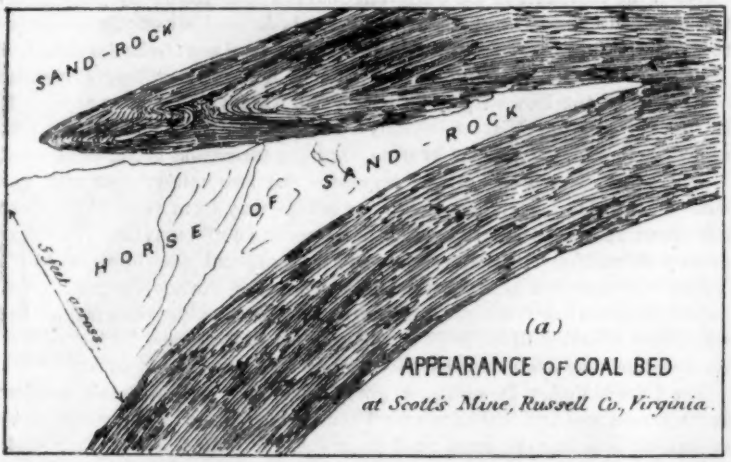
It is opened again at (*c*) some hundred yards higher up the creek, and on a *north* dip of 50°. The Confederate army mined it pretty extensively. It is here three feet thick, in three benches each a foot thick. The top and bottom benches good, the middle bench bony. Over it are three or four feet of slates, and then comes a one-foot bed of bony coal. The report goes that the miners found these two coal beds close together, down below; making thus one very fair *four-foot coal bed*. A diagram on the next page shows the whole exposure in position.

All this is not very encouraging for the coal trade. But the same bed has been opened at (*d*), directly on the crest of the anticlinal, which has here sunk (running in an easterly direction) to the level of the creek. Here

the coal lies flat in the water; and several pits, sunk through it, are deeper than the height of a man. The bed must be nearly, or quite, six feet, and yields good coal (as indeed it does at the other openings); but what its constitution may be I do not know. It is probably subdivided into benches of different qualities; and, no doubt, has some of the slate of the above last section running through it. Its position on the anticlinal will make mining difficult.



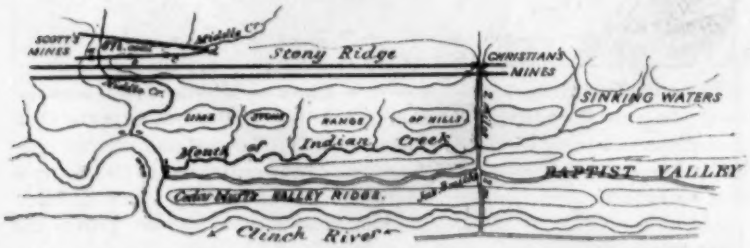
The anticlinal disturbance at Scott's Mines on Middle Creek must be local; because the topography around the Salt Well shows that the Coal Measures *there* come up to the Downthrow in a flat and undisturbed condition; and the dying down of the crown of the anticlinal in the Six-foot bed so rapidly that the bed lies flat in the creek only a few hundred yards above where it plunges at angles of 40°, 50° and 60° proves the same thing.



Nevertheless, the very steep dips of the overlying coal beds and rocks throughout the body of Stony Ridge makes the whole disturbance of considerable magnitude; and I have no doubt that when it is well examined to the eastward, it will be found to run in that direction some miles; not, perhaps, as an anticlinal but as a downthrow; and it may very well be the Abb's Valley Downthrow, of which more hereafter.

LAUREL RUN COALS.

Leaving the curious topography of the Big Creek, Middle Creek, and Mouth of Indian Downthrow to be described hereafter, in connection with Paint Lick Mountain and its Iron Ore, and going east up Indian Creek Valley, I can only report coal mines on Laurel Run, a side branch coming into Indian from the northwest. Mr. Christian has here opened several beds, one of which is reported to be *much over* six feet thick. The coal is wagoned to the county-town of Tazewell, Jeffersonville, fifteen or seventeen (15 or 17) miles distant. The following sketch will show how the coal comes out to market—two miles to James Smith's, on the Baptist Valley Road (beautifully engineered, at low grades), formerly a turnpike, and still the highway between East Kentucky and Middle Virginia; two miles to the Clinch Valley Road; thirteen miles by either of these two roads to Jeffersonville:



What the character of the Christian Coal is I do not know by personal inspection; but it must come from the same beds, and be essentially similar to the Scott Coals, and also to the Abb's Valley Coal next to be described.

Just east of the Christian Mines runs a limestone valley, along the south side of the Downthrow, in which the waters sink into caverns. It is called "Sinking Waters." Any one familiar with Abb's Valley (15 miles further east) will see at once, that the formation is the same; but I will show that Stony Ridge separates the two valleys and that the coal areas which I have been following all the way from Wise County are cut off, or whittled down to a fine point, opposite Jeffersonville. The next cross-section, No. 8, will show how this is done, and also how the Abb's Valley coal beds are brought down to the present surface by quite a different Downthrow from the one we have been tracing thus far, all the way from Guest's River in Wise County; a Downthrow *behind* and to the *north* of this one; as the map in colors will also help to show.

The Clinch Valley Downthrow, going east from Indian Creek, catches in its jaws a less and less number of beds and width of coal ground, until at last, on crossing the great road from Jeffersonville north to Tug Fork of Sandy, it holds but the lowest coal bed, standing at a high angle and very little of it left.

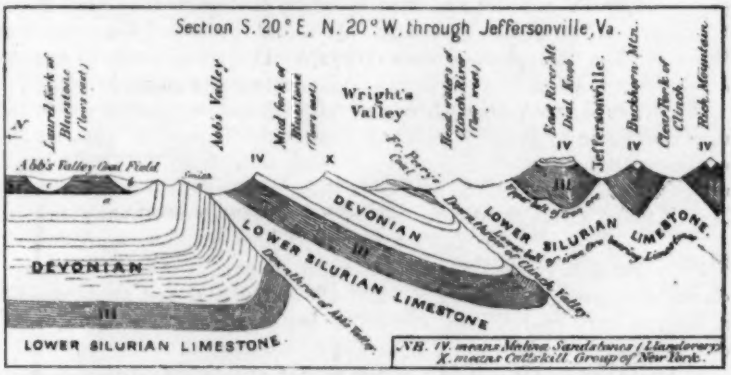
This is seen on the Section No. 8, marked Captain Frank Peery's Coal. How far east along this crack this coal can be traced. I do not know; but nothing of value can be expected from it; which is a great pity; for at this point *easy* access to the back country ends.

To get over into the Abb's Valley Coal Fields, two mountains must be crossed, or, rather steep stony hills, consisting of all the formations from the coal down to the limestone; especially Sandrocks X (Catskill) and IV (Shwangunk) here much diminished in thickness; which accounts for the comparative lowness of these mountains when compared with the high mountains formed by the increased outcrops of these formations in the Northern States.

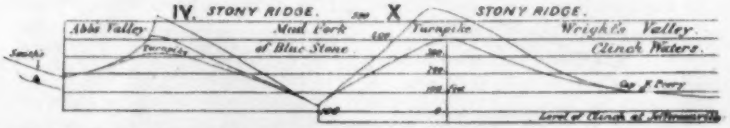
The deep rapid rocky bed of Mud Fork of Bluestone lies between the two mountains and descends eastward. Where the turnpike crosses it it is 400 feet below the notch in the crest of the first mountain, X (say 550 feet below the crest itself); and 250 feet below a slight notch in the crest of the second mountain, IV. This crossing of Mud Fork is, by barometer, on a level with the Jeffersonville Court House, and about 100 feet higher than the Clinch two miles east of Jeffersonville, at the west end of Wolf Creek Valley.

(Cross Section No 8, on the Map)

SHOWING THE ABB'S VALLEY DOWNTHROW.



The turnpike summit crossing the first mountain (X) is 300 feet above Captain Frank Peery's, on the head-waters of Clinch (6½ miles north of Jeffersonville). Clinch and Bluestone run in opposite directions along Wright's Valley; Clinch westward, Bluestone eastward. The divide between them is about 1¼ miles east of the turnpike, at Frank Peery's, and say 100 feet higher in level. This route from Greenbrier to Tazewell is feasible, but it is needless to try to get coal out that way.



Mud Fork of Bluestone heads up rapidly westward of the turnpike, and yet the valley between X and IV must continue on between the two Stony Ridges from the very necessities of the case.

Abb's Valley is produced by a great upthrow of the Lower Silurian limestone against the Coal Measures. The turnpike enters it almost at its head, or western end. From the notch in IV through which the road passes, to the Dry-water course in the centre of the valley is a descent (by barometer) of only 110 feet. Westward the valley rapidly fills up, and that is the course to take in locating a railroad from the mines out to Jeffersonville. A feasible route may be obtained, I think, by keeping up Abb's Valley to and over its divide, and down Cavitt's Run to the Clinch, two miles west of Jeffersonville.

The cause of the heading up of Abb's Valley and Mud Fork Valley so suddenly westward, and against what seems to be the main body of the Tug Fork of Sandy Coal Measures, is a most interesting and important affair, which should be investigated. I can only conjecture it. I take it to be likely that the Abb's Valley Upthrow of limestone starts across the Measures southwestwardly, becoming less and less of an upthrow, and thus swallowing down from the surface first, the Lower Silurian limestones of Abb's Valley, and then the shales and sandstones of the two stony ridges IV and X; and that it finally merges in the Clinch River Upthrow. At all events, such a geology would result in a topography of this sort: The limestone and shale valleys would head up suddenly against a ridge composed of Coal Measures Conglomerate or Sandrocks.

My advice is, that no coal-freight railroad line be sought for in the direction taken by the Jefferson and Tug Sandy Turnpike. But, on the contrary, that a line be sought further west, more down the Clinch, viz.: up Cavitt's Creek. Let the coal beds there be carefully explored, and a line be found across the divides beyond the west line of Abb's Valley.

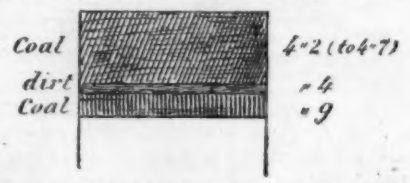
ABB'S VALLEY COAL.

Fifty feet below the summit of the hill, shown in the "Local Map" on the next page, and nearly 150 feet above the coal bed at its base, is a layer of very coarse, gray, friable sandstone, weathering yellow, without pebbles. Over it a tree has turned up a coal crop.

The coal bed below is, perhaps, the only workable bed of this district. For, after descending, at a slope of one or two (2°) degrees, south 20° east, through the base of the hill, and getting under water level, it seems to turn up suddenly and quite vertically, and to outcrop along the bottom of a little valley. It has been mined a little close to the turnpike (*b*) and Mr. Smith reports it to be "as wide as a room."

Ten miles east of this, and in a similar position, a coal bed is mined, which I judge to be the same one, and it is called ten (10) feet thick.

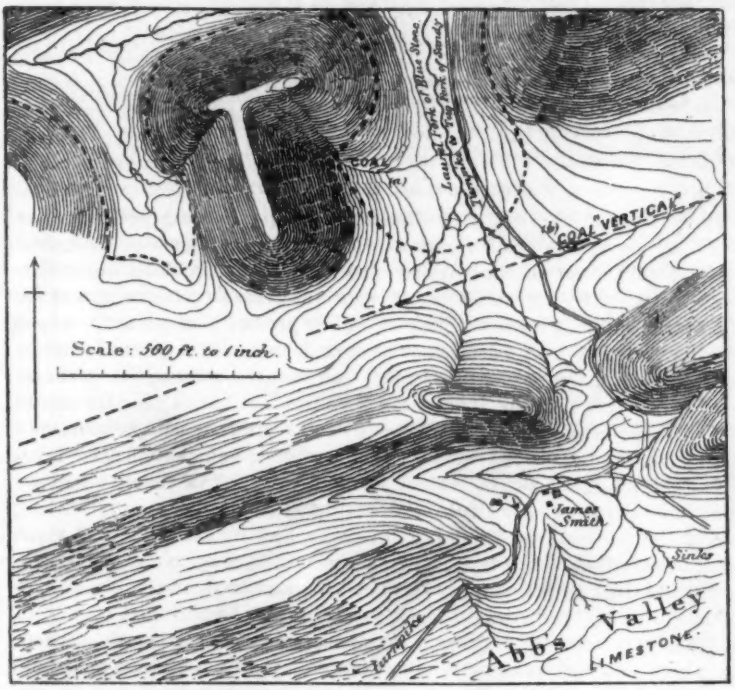
In the openings at the foot of the hill (at *a*) it has been merely thrown out from the water of the little brook. Mr. Cochrane, who has dug coal all through this region, gives its thickness as (5) five feet of coal in $5\frac{3}{4}$ of space. A dirt bed, four inches thick, separates the lower bench of very fine coal from the upper and main body of the bed.



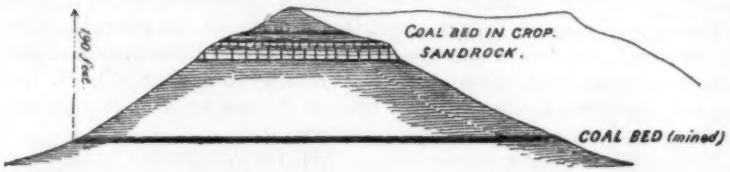
This coal bed is dug into by the farmers, at several places on the hill-sides of Laurel Fork, from half a mile to several miles north of Smith's coal. It is called six feet thick. Cochrane says he has dug it on Laurel where it was good seven feet.

LOCAL MAP OF ABB'S VALLEY COAL.

(Properly Blue Stone Coal.)



CROSS SECTION OF COAL IN HILL.



The level of the coal opening is (by barometer) 115 (one hundred and fifteen) feet above Smith's house; which house is 125 feet below the summit of turnpike crossing, Stony Ridge (No. IV). [See p. 504.] The coal and the turnpike summit are, therefore, nearly on a level.

From these coal outcroppings just back of Abb's Valley the coal field

of West Virginia and Eastern Kentucky extends, without a break, to the Ohio River. And the south edge of this coal field is the north ridge of Abb's Valley. The coal beds can be opened anywhere in the hills, just north of Abb's Valley; and several low windgaps, similar to that at Mr. Smith's, give the people of the valley access to the coal field. But, as I have said before, the railway line which passes through Tazewell must approach the coal field from the west—not from the south; around the head of Abb's Valley, from Cavitt's Creek. This will also subserve the interests of any railway projected from the Ohio River up Tug Fork of Sandy to Jeffersonville.

(N. B.—I do not feel entire confidence in my geology of the sandstone ridges at Smith's,—the ridges which form the north boundary of Abb's Valley. They need much more careful study than I could give them.)

THE IRON ORES OF II AND V.

The valleys of Tazewell and Russell, in Virginia, being geological, as well as geographical, prolongations of the interior limestone valleys of Pennsylvania, such as the Nittany, Morrison's Cove, and Kishicoquilis, contain necessarily the same kinds of ore, in the same formations, and in the same conditions. I mean that the unbroken ground is at present covered with patches of brown hematite "blossom," just as the ground used to be where our charcoal furnaces stand; and that the color of the road and field soil is the same as that of our best iron ore banks; the limestone rocks project in the same style, have the same internal composition, and exhibit the same corroded and dissolved surfaces; and potholes, caverns, and sinks abound along certain lines of outcrop. All these things are now known to bear an intimate relationship with both the original setting free of the mineral iron from the limerocks, and its subsequent deposit and consolidation. And it seems to be becoming clear to our geologists, that while there are regularly stratified beds and belts of the ore at two or three distinct horizons in the Lower Silurian Limestone Formation, which may be traced for many miles along the strike of the rocks, there are also vast accumulations of this brown hematite ore along anticlinal axes, especially wherever these are fractured; or degenerate into pure upthrow faults. It stands to reason that such a line of fracture, with a high wall on one side of it, should, in the course of thousands of ages, have collected vast quantities of the peroxidized iron which was being, through all these ages, set free in the slow dissolution of the limestones and the reduction of the whole mass of upheaved country to its present level. To say nothing of the facility afforded by such fissures to the decomposing and recomposing agency of drainage waters.

It is along the great upthrow fissures, then, that we are first to seek the iron ore deposits of this section of Virginia. And such a spot was pointed out to me near the mouth of Lick Run, on the hills bordering the north bank of the Clinch River, in Russell County, at section line No. 4 upon the map. Large masses of "blossom" lie scattered about the fields.

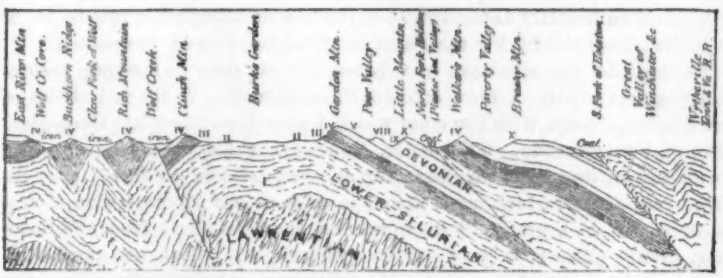
Similar shows of ore occur in other places. The hills southeast of Jef-

fersonville, just outside the town, show the existence of ore beneath the surface. Great quantities are reported two miles east of the town; and still more abundant exhibitions in the cove of Wolf Creek, behind Buckhorn Ridge, north of the forks of Wolf Creek, and opposite Rocky Gap. Immense shows are reported in Wolf Creek Valley, inside of (or south of) Rocky Gap.

I have myself no doubt of the correctness of these reports, so far as surface exhibitions are concerned. And it is an old and good iron master's maxim, that where there is plenty of blossom there will be plenty of good ore. The fact is geologically exact. For the blocks of ore on the surface of limestone land (like the masses of white quartz on the surface of a mica slate country) are the undissoluble parts of the original country left behind by the slow and imperceptible mouldering away and removal of the softer material.

A downthrow fissure, also, traverses Wolf Creek, at the foot of Clinch Mountain, as shown in the following continuation of section 8, and this fissure brings the No. IV sandrock of the mountain (which surrounds Burke's Garden) at a dip of 30°, down against the limestone of the valley. How far this fissure extends eastward I do not know; but certainly beyond Rocky Gap.

CONTINUATION OF SECTION No. 8 (OF THE MAP) SOUTHWARD.



There is also a sharp, broken anticlinal axis running through the valley of the Clear Fork of Wolf Creek, and this would favor the accumulation of iron ore. Another traverses the cove behind Buckhorn Ridge, cutting it off from East River Mountain. It is on this anticlinal that the Wolf Creek Cove ores exhibited.

But there is another important fact not to be lost out of view. Through out Southern Pennsylvania, and as far eastward (along the belt of which we are treating) as the Lehigh and the Delaware, and so on through New Jersey in the one direction, and through Maryland and Virginia in the other direction, the horizon (or formation level) of the bottom of the Lower Silurian (formerly called "Hudson River") Slates, No. III, and the top of the Lower Silurian Limestones, No. II, is a plate of brown hematite iron ore-bearing rocks. Many of our best and oldest mines, like the Balliott and the Moselem, between the Schuylkill and the Lehigh, are on the outcrop of this horizon, at the top of the limestone formation. Where

the dip is low and the slates of No. III are thick, this line runs through the middle of our limestone valleys. Where the dips are steep and the Slate Formation No. III is not so thick, the latter forms the flank of the mountain, and the iron ore line runs at the base of the mountain. Where a closely folded anticlinal makes the valley so narrow that the two bases of the opposing No. III Mountains touch each other, and the ridge of the limestone formation No. II, juts up along the water course, or does not quite come to the surface (as in the three valleys at the left hand side of the above Section No. 8), the iron ore deposits must be abundant.

Holding these simple principles of structure in mind, it is evident that the great iron bearing formation, at the base of the No. III Slate Formation, keeps its character all through Middle and Southern Virginia, and will be as rich and certain a basis for large iron mining and iron smelting operations as any other and better known section of the Appalachian Mountain Belt between New York and Alabama.

An old forge at the west end of Paint Lick Mountain (between Lebanon and Jeffersonville) used this top-limestone-horizon ore; and I have no doubt of its abundance in many other places. It is more constant and regular than the ores further down and near the bottom of the Limestone Formation No. II. And these, moreover, are often swallowed up to such a depth by the downthrows as not to be attainable for many years.

It remains to notice a quite different variety of iron ore, which, I hope, will prove sufficiently abundant at a few points along your line of road. It is the Fossil Ore of V; the Paint or Dye-stone Ore of Tennessee.

To describe the situation of this ore, I must refer to the map accompanying this paper. I have colored Formation No. V, the red shales of the Clinton Group, with the color which I gave it on the State Geological Map of Pennsylvania. This color, however, is not appropriate to the formation in Southern Virginia; for the *red soil* and *reddish* (Upper Silurian) *sandstones* which mark the slope sides of our Pennsylvania Mountains (of No. IV), gradually disappear as one goes south from the Potomac, giving place to a gray soil and very slightly, often not at all, reddened sandstones and slates. On the other hand, the opposite side of the mountain, where the basset edges of the (Lower Silurian) slates of No. III crop out, is very red. A Pennsylvanian geologist floating over the country in a balloon would naturally make the mistake of just reversing the geology of the mountain, and would descend upon the wrong side of it to seek for the well-known and highly prized fossil ore bed of Danville and Frankstown.

In spite of this change of color in the formation soils of the region, I have thought it best to retain the red color for No. V upon the map, seeing that it represents the blood-red color of the fossil ore itself. One may see, then, by tracing the lines of color on the map, where the fossil ore bed *ought* to be; whether it be there or not. Very extensive and costly explorations have been necessary in Pennsylvania and Maryland. No doubt much research of the same sort will be called for in Virginia. But the ore is there; and, as in Pennsylvania and Tennessee, it will run for

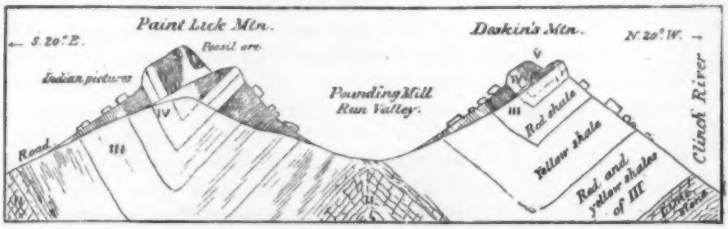
miles together in a workable condition as to size and posture, and prove a source of wealth.

The principal use of this ore is to mix with other varieties,—with the blue carbonate lean ores of the Coal Measures, especially; but also with the inferior grades of brown hematite. The time will come when it will be smelted in connection with the primary ores of the Blue Ridge Range and Smoky Mountains.

The forge which stood many years ago at the west end of Paint Lick Mountain, in Russell County, used this ore, and obtained it from the summit of Short Mountain to the south.

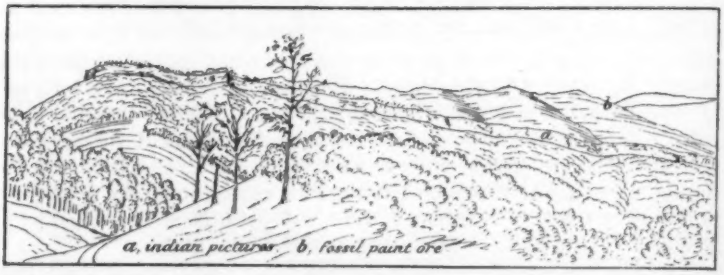
Paint Lick Mountain is named from an exposure of this ore on its summit. The situation is one of peculiar interest to the geologist and to the antiquarian.

CROSS SECTION AT THE ROAD FROM THE CHURCH TO CLINCH RIVER ABOVE CEDAR BLUFFS; AT LYLE'S GAP.



A cross-section, at the road over the mountain, through a notch called Lyle's Gap, will show the cause of the appearance of this ore in so singular a position. It is confined to the very summit of the mountain for some distance midway between the two ends, and to the west of the place where the road crosses. Its thickness and extent is unknown, nor do I think that more than a few thousand tons of it are to be expected. The ore stratum has been swept away from all other parts of the ridge of the mountain, and no trace of it has been left upon Deskin's Mountain; from

PAINT LICK MTN, FROM THE SOUTH; CLIFFS AND ORE.



which, indeed, the great sandrock No. IV has almost disappeared; a few house and barn-like masses being left standing at its western end in most picturesque style. House and Barn Mountain is a prolongation of Paint

Lick synclinal westward and is named from two masses of No. IV, left upon its summit, visible from all the surrounding country. Dial Knob (East River Mountain) and Buckhorn Mountain are prolongations of Paint Lick and Deskin's synclinals, eastward beyond Jeffersonville, and Dial Knob may have a good deal of fossil ore left upon it in the cove, behind the Dial Cliffs; but Buckhorn has lost the ore. So has the whole range of Rich Mountain, from Rocky Gap west, to Morris's Knob, which is terminated by one of the most remarkable cliffs of No. IV I ever saw (see its profile below). Short Mountain is a prolongation of Rich Mountain westward, broadened by a shallow synclinal which must hold large quantities of the fossil ore. The synclinal of House and Barn Mountain is prolonged westward (past Lebanon, far down Clinch River) as a downthrow of the No. V Formation against the limestone of No. II; and all along the south side of Copper Ridge there runs a south dipping plate of

DOUBLE ESCARPEMENT OF No. IV. 200 Ft. WALLS,
at the Westend of Rich Mountain, Morris Knob, Russell Co, Va.

the fossil ore, which has been opened, in old times, at one point, and used in a now abandoned forge. There must be immense quantities of the ore in this ridge. It is known to the inhabitants, however, only as a paint. But this will be a sufficient guide to the iron master.

The Indians used the outcrop of the fossil ore bed to paint their faces and lodges. The deposit on Paint Lick Mountains was a famous locality among the Aborigines. On a smooth perpendicular wall of sandstone, facing southward, and visible from General Bowen's house and the Maiden Spring, there remain numerous pictures and symbols of men and animals in red paint, fresh as when first made, and older than the settlement of the country by the whites. I give above a view of this long wall of sandstone cliffs as I saw it from the Lebanon–Jefferson turnpike; and, when taken with the cross-section, it will explain without further words both the structure of this (and other similar mountains) and the cause of the small amount of fossil ore left upon its summit, and the total disappearance of the last remains of the ore deposit from the summits of House and Barn, Desmit, Buckhorn, and Rich Mountains.

But there are extensive outcrops of the fossil ore of No. V along Poor Valley; in fact the deposit (whether rich or not remains to be discovered) runs uninterruptedly more than a hundred miles in an almost mathematically straight line along the south flank of the Clinch Mountain from

Tennessee, past Moccasin Gap, back of Saltville, past Sharon Alum Springs, to Hunting Camp and Kimberling Creeks, and so on, eastward, across New River towards the James River country. No doubt some sections of this line hold the ore bed in a lean and, perhaps, unworkable condition; but it is quite incredible that other sections will not have it both thick and rich.

Now it is along this Poor Valley and its outcrop of iron ore that Gen. Haupt locates the line of railway.

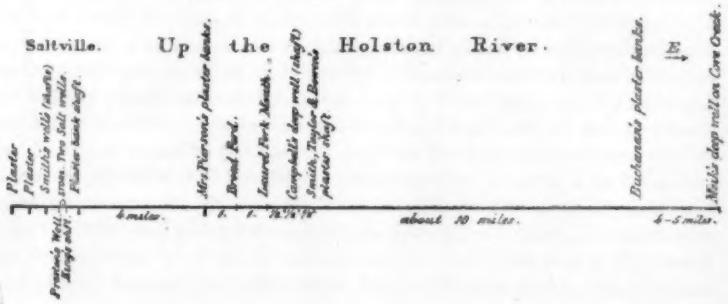
Even if the Clinch River line be adopted, for the sake of the coal and for other reasons, a branch road must certainly be made up Hunting Camp Creek to the Plaster Banks, at Saltville; and this branch will have the ore crop of Poor Valley, and the ore deposits of Tumbling Run, on top of Short Mountain, at its command. It can bring the fossil ore forward to the Forks of Wolf Creek, where are the before mentioned large deposits of brown hematite ore; and where it will meet the coal coming across from the Clinch River. Here, or somewhere lower down Wolf Creek, perhaps at its mouth, will probably be located one of the principal future iron-works of Southwestern Virginia.

THE PLASTER (GYPSUM) BANKS, AT SALTVILLE.

A sound theory of the origin of the gypsum can be, for the present, our only guide to a correct estimate of its quantity, where it is known to exist, and to its discovery elsewhere.

Gypsum may be produced by the action of free sulphuric acid on limestone; or by the action of sulphuretted hydrogen gas on limestone. One or the other, or both of these agents combined, have acted on the limestone rocks along the banks of the N. Fork Holston River, from Saltville, eastward for a number of miles, converting them into gypsum. The acid, whether in a fluid or in a gaseous form, has undoubtedly passed along between the walls of the great fissure which has thrown the Lower Coal Measures of the Poor Valley (Little) Mountain 15,000 or 20,000 feet down against the limestones; has soaked into the walls of the fissure; and has changed the limestone to gypsum for many yards on each side of the crack. Shafts have been sunk through solid masses of gypsum rocks thus formed to a reported depth of 500 and 600 feet, finding no bottom to the gypsum.

The story of this shafting as given to me by General Bowen is as follows:



Captain Smith and his son-in-law Mr. Robinson many years ago sank a line of shafts across the (tertiary or postertiary) plain on which Saltville stands, and *all of them* through gypsum *all the way down*. Others were sunk by Smith & Robinson, Campbell, Taylor & Bowen, Meik and others at other places in the Holston Valley for a length of twenty (20) miles, more or less, and up Cove Creek four or five miles still further east. No attempts were made to get the plaster further on towards Sharon Alum Springs; but there is nothing to intimate its non-existence except the absence of outcrops through the soil. These outcrops naturally existing, or accidentally exposed in farming, or by the railroad cuttings south and west of the village, have alone (as it seems) determined the search after gypsum in the valley. And as the Saltville people alone have any proper machinery for sending it to market, a stop has been put to all exploration elsewhere.

Moreovor, seeing that Capt. Smith struck a copious brine in two of his wells, the opinion early prevailed that the salt and the gypsum were geologically connected. This opinion induced a number of persons to sink *in the gypsum outcrops* not for gypsum but *for salt water*. As salt water was obtained in no single instance other than Capt. Smith's two wells, all hope of obtaining brine and making salt elsewhere than at Saltville has been long since abandoned; and consequently all exploration of the gypsum rocks, which had no commercial value to the salt-well borers.

It is therefore probable that the limestone wall (the south wall) of the Holston River Downthrow (Upthrow of limestone) will in course of time be discovered to be converted into gypsum at other points besides those specified above; and that the gross quantity of gypsum existing beneath the surface along this part of the Holston River far exceeds any estimate which I can make from the gypsum banks already opened. And for the same reason it is probable that the limestone walls of the other Upthrows of the region will be found turned into gypsum, at least in certain places, and in very considerable abundance.

The appearance of brine in such quantity and of such strength must be considered as a local phenomenon explainable without reference to the gypsum. Such an explanation may be found in the very curious lake-deposit of the little triangular plain of Saltville; a deposit evidently made in a deep little lake or pond basin filled with red mud saturated with salt-water, gypsum drainings, &c., &c. In this mud the salt-water has deposited rocksalt, and from this rocksalt deposit now rises the copious discharge of brine which furnishes all the supply needful for the extensive salt works. The salt lies in solid form, mixed and inter-stratified with compact red marl or clay, 200 feet below the water-level of the Holston; and the borings have gone down (at the Salt Works) 176 feet further without reaching the bottom! On the top of the deposits of salt and mud is a stratum of blue slate more than 100 feet thick. Over the blue slate lie 60 or 80 feet of gypseous clays. The limestone country being cavernous to great depths, and especially along the face of the Downthrow, it is not surprising to notice that the level of water stands the same for all the wells and shafts sunk at Saltville and rises and falls in sym-

pathy with the Holston River. This accounts for the inexhaustible supply of liquid. The heaviest pumping has no perceptible effect in lowering the level.

In 1853 the salt yield was 300,000 bushels; 50 lbs. to the bushel, and 6 bushels to the barrel; at 50 cents a bushel. Five furnaces were then running 24,000 gallons of brine pumped daily; 10,000 cords of wood burned yearly.

During the Civil War, four wells were pumped night and day for six months, and yielded 1,000,000 bushels of salt during that half year. There were then sixty-nine different "blocks of kettles" going. These kettles, broken and rusty, lie scattered about the valley for six miles, half buried in piles of burnt and broken down walls which represent the various works then in full operation. Some of the salt water was carried in railway tanks nine miles to Glade Spring Station on the Virginia and Tennessee Railroad, and boiled there.

At present there are three "blocks," of 80 kettles each, (5 bushel to a kettle) per 24 hours, making 360,000 bushels per year, of 300 days.

Preston's gypsum banks yielded 2000 tons in 1854; the cost at the mines, in lump, being $3, and in flour $5; eighty miles distant $20.

What the yield has been since and what it is now, I do not know. Operations are vigorously carried on at four or five shafts. Plaster is now sold at the mines for $2.50 the ton; at Sharon Alum Springs, 35 miles to the eastward, at $10, in wagons; and is carried forty miles further east for use upon the soil. Its virtues are well known and highly prized. It *doubles* the grass crop and grain, and greatly improves corn. One bushel of 100 pounds is sown to the acre.

A railway from Saltville east would find a market for all the plaster it carried. Plaster would go east to the Wolf Creek Fork Junction, and return by the other line to be used on the pasture lands of Tazewell and Russell and Wise Counties. But its greatest commercial outlet would be towards Staunton and Winchester.

Although the gypsum rocks have not the regularity of a coal bed, and some difficulties, of a kind peculiar to this district will be encountered when mining operations are extended to cope with the demands of commerce along a great trunk railroad, yet I see no practical limit to the capacity of the gypsum belt for exploration. Shafts five and six hundred feet deep have permitted the miners to feel the gypsum masses for fifty yards in width. Such a mass, limited by such a shaft, weighs six or seven hundred thousand tons, provided the gypsum be solid the entire depth of the shaft, &c., &c. This is not the case; neither, on the other hand, is the *width* of the column of gypsum limited to fifty yards, or to any other figure. Nothing can be more irregular than the masses of gypsum underground—unless it be the course to be taken to get it out to the surface. In spite of all mining difficulties the value and scarcity of the mineral in all other parts of the country must make its mining in this district always extremely profitable, and its railway carriage over long disances inevitable. It must always be in demand; can always pay a high freight charge, and cannot meet with competition from the Nova Scotia plaster until it arrives within a hundred miles or so of tidewater. Westward and southward it may go five hundred miles without meeting competition.

Stated Meeting, Sept. 20, 1872.

Present, nine members.

Vice President, Mr. FRALEY, in the Chair.

A Photograph was received from Mr. A. H. Worthen, dated, Springfield, Ill., August 31, 1872.

Letters of acknowledgment were received from the Congressional Librarian, Sept. 5th (Proc. Vol. 1. Catalogue I., II.), the Boston N. H. S., May 15th (XIV., iii. 86, 87,) and the London Geological Society (XIV., iii. 86.)

A letter of envoy was received from the New York State Library, dated August 30.

A letter describing the Museums and Libraries of Oxford, England, was received from Mr. W. A. Smith, Professor of Moral Philosophy in Columbia, Tennessee, Athenæum, dated, Sept. 14th, 1872.

A letter was received from D. C. H. Stubbs, dated July 8th, 1872, respecting the purchase of copies of Photographs of Indian Sculpture. On motion the Secretary of the evening was authorized to purchase a set after due examination of their value.

Donations for the Library were received from the Horticultural Society in Berlin, the Prussian Academy, the Observatory at Turin, the Geographical Society, Revue Politique, and Lartêt family at Paris, the Edinburg Observatory, the Meteorological Office in London, Nature, the Canadian Naturalist, Essex Institute, Old and New, Dr. S. A. Green of Boston, American Antiquarian Society, American Journal of Science, and Professor O. C. Marsh of New Haven, American Chemist, Mr. W. W. Mann, the Dudley Observatory, New York State Library, N. J. Historical Society, Franklin Institute, Medical News, Journal of Pharmacy, and Prof. Edwin J. Houston of Philadelphia, the Petroleum Monthly, the U. S. Observatory, Bureau of the Interior, Prof. F. L. O. Röhrig, the Smithsonian Institution, Bureau of U. S. Engineers, and the Wisconsin Historical Society.

The death of Mr. Jacob R. Eckfeld at Haverford, near

Philadelphia, August 9th, aged 70, was announced with appropriate remarks by Mr. Patterson.

On motion, Mr. Dubois was appointed to prepare an obituary notice of the deceased.

The death of Dr. John Bell of Philadelphia, August 19th, aged 77, was announced by the Secretary.

On motion, Dr. B. H. Coates was appointed to prepare an obituary notice of the deceased.

Communications were received from Prof. E. D. Cope under the following titles:

Third account of New Vertebrata from the Bridger Eocene of Wyoming Territory.

Notices of New Vertebrata from the upper waters of Bitter Creek, Wyoming Territory.

Second notice of Extinct Vertebrates from Bitter Creek, Wyoming Territory.

On the existence of Dinosauria in the Transition beds of Wyoming Territory.

On the Dentition of Metalophodon.

The Secretary announced that he had received a telegram from Prof. Cope, dated Black Buttes, Wyoming Territory, August 17th, announcing the discovery of Lefalophodon dicornutus, bifurcatus, and excressicornis, Cope.

Prof. Edwin J. Houston called the attention of the Society to a remarkable instance of the acoustic sensitiveness of matter. "While visiting a number of water-falls on Adam's Brook, Pike Co., Pennsylvania, I noticed one in which a scanty supply of water was dripping, in thin delicate streams, from the moss covered walls of a precipice. The day was unusually calm, and the veins were remarkably free from ventral segments for a considerable distance from the filaments of moss from which they issued. Struck with this circumstance the idea occurred to me to test the sensitiveness of the stream to sound pulses. I made the attempt, and after several trials found a note, a shrill falsetto, to which they would respond.

The experiment was one of extreme beauty. At one point

of the falls, there were no less than one hundred of these streams, and on sounding the required note the groupings of the drops and the positions of the ventral segments instantly altered in quite a marvellous manner. This case of acoustic sensitiveness is one of the most extensive I have ever noticed.

A second fall was found that would respond to certain notes, though it was not equal to the first in sensitiveness.

Though not able, from a sudden flooding of the streams, to discover the exact conditions for success, I believe the explanation of the phenomenon to be the same as that now generally given for sensitive smoke and water jets, viz: that the sound pulses produce a vibration of the orifice of the jet, by which the constitution of its issuing stream is altered. The orifice in the case is replaced by the thin moss filaments, which are surrounded by the stream instead of surrounding it. From their shape and position their filaments, acting as reeds, readily accept the motion of the sound waves and so alter the constitution of the vein."

Prof. Chase communicated observations on Daily Auroral and Meteoric Means, and on some new correlations of stellar and Planetary distances.

Mr. Lesley described a newly observed terminal moraine crossing the Walkill Valley at Ogdensburg near Franklin, Essex county, New Jersey.

Pending nominations, Nos. 697 to 701 and new nomination No. 702 were read.

The meeting was then adjourned.

DAILY AURORAL AND METEORIC MEANS.

By Pliny Earle Chase.

(*Read before the American Philosophical Society, Sept.* 20, 1872.)

The apparent influence of meteoric falls upon auroras, which is indicated by the five-day means, (*ante* p. 402), renders more minute observations desirable, in order to ascertain to what extent a similar influence may be traceable in the daily means.

The only available observations that have fallen under my notice, from which any satisfactory approximation can be made to the daily meteoric curve, are embodied in Baumhauer's table of the recurrences of meteoric stones and fire-balls, quoted by Lovering, ("on the Periodicity

of the Aurora Borealis," p. 220). Lovering observes that the days signalized by the frequency of these phenomena are also days which, according to Quetelet, are distinguished by extraordinary numbers of shooting stars. I have grouped the second means of Baumhauer's numbers in five-day periods, and calculated the ratio of each ordinate to a mean ordinate of 100, in order to justify the following comparison with the auroral ordinates, which were similarly computed from Lovering's table.

FIVE-DAY AURORAL AND METEORIC NORMALS.

(A.=Auroral, *Lovering*. M.=Meteoric, *Baumhauer*.)

	A.	M.		A.	M.
January 3,	110	119	July 2,	40	35
" 8,	110	128	" 7,	46	51
" 13,	114	116	" 12,	44	83
" 18,	113	96	" 17,	40	113
" 23,	110	89	" 22,	39	121
" 28,	111	98	" 27,	45	121
Feb. 2,	113	111	August 1,	49	136
" 7,	116	115	" 6,	51	160
" 12,	125	105	" 11,	60	160
" 17,	133	91	" 16,	76	134
" 22,	134	90	" 21,	88	103
" 27,	132	97	" 26,	95	74
March 4,	129	103	" 31,	102	65
" 9,	133	106	Sept. 5,	112	86
" 14,	145	101	" 10,	123	110
" 19,	144	88	" 15,	131	106
" 24,	138	82	" 20,	138	88
" 29,	138	91	" 25,	142	86
April 3,	133	103	" 30,	139	99
" 8,	130	108	October 5,	133	108
" 13,	131	98	" 10,	129	108
" 18,	118	76	" 15,	129	108
" 23,	94	63	" 20,	133	111
" 28,	79	66	" 25,	132	105
May 3,	76	69	" 30,	126	95
" 8,	66	71	Nov. 4,	120	106
" 13,	61	86	" 9,	121	143
" 18,	57	100	" 14,	129	170
" 23,	51	96	" 19,	127	156
" 28,	47	88	" 24,	113	132
June 2,	44	85	" 29,	109	125
" 7,	44	82	Dec. 4,	115	125
" 12,	41	73	" 9,	122	125
" 17,	35	57	" 14,	127	123
" 22,	31	38	" 19,	125	111
" 27,	36	31	" 24,	114	99
			" 29,	111	103

In each curve there is a tendency to monthly maxima, the tendency being least evident in the summer months.

The principal minimum in each curve is in June.

There are nine marked maxima in each curve, of which those in the months of January, February, March, April, September, October and November, are the most nearly accordant. These maxima are as follows:

A. Jan. 13. Feb. 22. Mar. 16. Apr. 13. .... July 7. .... Sept. 25. Oct. 20. Nov. 14. Dec. 14.

M. Jan. 8. Feb. 7. Mar. 9. Apr. 8. May 18. .... Aug. 6. Sept. 10. Oct. 20. Nov. 14. ....

Two of the maxima are synchronous in the two curves; three occur in the auroral ordinate which follows the meteoric ordinate; two occur in the third subsequent ordinate, one of the two being midway between a precedent and subsequent meteoric ordinate. The accordances and the discrepancies may perhaps be explained by the hypothesis of lunar perturbations.

The daily curves present a similar accordance in the number of maxima and minima, but in consequence of the frequent uncertainty whether the auroral or the meteoric should be regarded as the precedent influence, they do not seem to furnish any additional data for satisfactory conclusions.

By variously grouping the auroral observations on each side of the days that have been designated by Wolfe and Kirkwood as rich in meteoric displays, or on each side of the middle days of meteoric periods, a variety of curves may be formed, of which the three following sets of ordinates furnish examples:

Days.	−7	−6	−5	−4	−3	−2	−1	0	+1	+2	+3	+4	+5	+6	+7
α	100	99	100	102	104	106	106	104	103	105	107	108	106	101	99
β	99	99	97	97	97	99	101	101	100	101	102	102	104	104	102
γ	103	102	101	98	97	98	98	99	101	101	101	103	105	101	98

These curves indicate a connection of meteoric displays with increasing auroral displays, together with a slight subordinate tendency to auroral maxima within one day of a meteoric display.

Although the æthereal disturbance, which is manifested by the auroras, appears to follow, more often than it precedes, meteoric falls, it seems probable that both phenomena are often dependent upon lunar perturbations or other extraneous causes. In such cases, the auroras may become visible before the meteors have reached the earth's atmosphere, and been made incandescent by friction.

STELLAR AND PLANETARY CORRELATIONS.

By Prof. Pliny Earle Chase.

(*Read before the American Philosophical Society, Sept.* 20, 1872.)

Mercury's mean distance may be grouped with the mean distances of other primary planets, so as to form the two following series:*

* In each table, C denotes the logarithm of the computed value; O, the logarithm of the observed value; E, the percentage of error in the computed value; L, the limit of retardation by solar rotation and of possible solar atmosphere; M, modulus of light. The fundamental unit is the suns's radius. The origin of the co-ordinates is taken at the intersection of the axis and the directrix.

(I.)

C.	O.	E.
.178352		
.467972		
.786253		
$\frac{3}{8}$ L .1.133195	1.135133	—.004
$\frac{5}{9}$ " 1.508798	1.509949	—.003
☿ 1.913062	1.919977	—.016
⊕ 2.345987	2.332155	+.032
2.807573		
♄ 3.297820	3.311651	—.032
♆ 3.816728	3.809811	+.016

(II.)

C.	O.	E.
.115730		
.732349		
$\frac{3}{5}\times\frac{5}{9}$ L 1.335303	1.333858	+.003
☿ 1.924592	1.919997	+.011
♂ 2.500216	2.513999	—.032
♃ 3.062175	3.048392	+.032
♁ 3.610469	3.615063	—.011

If the limiting radius of solar retardation (L —36.4, see *ante*, p. 415) be regarded as also a limit of explosive oscillation, and if radii terminating in the cardinal points of the explosive excursion ($\frac{1}{6}$, $\frac{1}{5}$, $\frac{2}{9}$, $\frac{1}{3}$, $\frac{4}{9}$, $\frac{2}{3}$, $\frac{8}{9}$) be employed for determining a parabolic series, the mean distances of Venus, Earth, and Jupiter, will be represented by succeeding abscissas of the same series, as in Table III.

(III.)

	C	O	E
	.127899		
	.291712		
	.453089		
$\frac{1}{6}$ L	.612030	.606859	+.012
$\frac{1}{5}$ "	.768535	.782950	—.034
$\frac{2}{9}$ "	.922604	.907889	+.034
$\frac{1}{3}$ "	1.074237	1.083980	—.023
$\frac{4}{9}$ "	1.223434	1.208919	+.034
$\frac{2}{3}$ "	1.370195	1.385010	—.035
$\frac{8}{9}$ "	1.514520	1.509949	+.011
	1.656409		
	1.795862		
	1.932879		
	2.067460		
♀	2.199605	2.191493	+.019
⊕	2.329314	2.332155	—.007
	2.456587		
	2.581424		
	2.703825		
	2.823790		
	2.941319		
♃	3.056412	3.048392	+.019

If the determining series be modified by substituting L for $\frac{8}{9}$ L, and employing $\frac{4}{3}$ L for the succeeding determining abscissa, Mercury's perihelion

and aphelion, and the mean distances of Venus, Mars and Jupiter, will be represented by succeeding abscissas of the same series, as in table IV.

(IV.)

	C	O	E
	.047818		
	.187943		
	.330020		
	.474049		
$\frac{1}{9}$ L	.620030	.606859	+.031
$\frac{1}{6}$ "	.767963	.782950	—.035
$\frac{2}{9}$ "	.917848	.907889	+.023
$\frac{1}{3}$ "	1.069685	1.083980	—.033
$\frac{4}{9}$ "	1.223474	1.208919	+.034
$\frac{2}{3}$ "	1.379215	1.385010	—.014
1 "	1.536908	1.561101	—.057
$\frac{4}{3}$ "	1.696553	1.686040	+.025
☿ I	1.858150	1.850507	+.018
☿ II	2.021699	2.021443	+.000
♀	2.187200	2.191493	—.010
♀⊕*	2.354653	2.353070	+.004
♂	2.524058	2.513999	+.023
	2.695415		
	2.868724		
𝔘	3.043985	3.048392	—.010
☿ —Ψ†	3.221138	3.211038	+.024

In a communication which I presented to the Society, May 16th, 1872, I indicated some simple relations between the superficial gravity and the times of rotation of the Sun, Jupiter and the Earth. If those relations are, as I believe, determined by an influent force, we may reasonably look for some analogous relations between our own and other stellar systems.

In the solar-focal parabola which passes through α Centauri and has its directrix in a linear centre of oscillation of a solar diameter, twenty-seven successive abscissas may be taken in regular progression,

$$\left[{}^{x}_{n} = \xi^{(n^0)}\, \eta^{\pm (n^1)}\, \zeta^{(n^2)} \right]$$

between the star and the Sun's surface, nine of which will be extra planetary, nine will be in simple planetary relations, and nine will be intra-planetary.

The upper extra-planetary abscissa bears nearly the same ratio to the modulus of light, as L bears to solar radius.

The limiting abscissas of the planetary series are determined by combining diametral centres of oscillation ($2\times\frac{3}{5}$), with centres of explosive condensation ($\frac{5}{6}$), and of explosive oscillation ($\frac{5}{6}$).

The planetary series, between these limits, is $\frac{1}{2}$ ♀, $\frac{3}{5}$ ⊕, $\frac{3}{4}$ ♁, $\frac{4}{5}$ mean asteroid, $\frac{5}{6}$ 𝔘, $\frac{6}{7}$ ♄, $\frac{7}{8}$ ☉.

* Mean centre of gravity of ☿ and ⊕ at heliocentric conjunction.

† Mean centre of gravity of all the planets, at heliocentric conjunction.

The co-efficient of the inner limiting planetary abscissa ($\frac{1}{3} \times \frac{5}{6}$ ☿) is nearly equivalent to the co-efficient of the exterior intra-asteroidal abscissa ($\frac{3}{4}$ ♁).

The co-efficient of the outer planetary abscissa ($\frac{1}{3} \times \frac{5}{6}$ Ψ) is nearly the reciprocal of the co-efficient of the inner extra-asteroidal abscissa ($\frac{5}{6}$ 2).

The middle abscissa of the planetary series corresponds very nearly with the inner limit of the asteroidal belt (Flora — 2.674854), as well as with $\frac{1}{3}$ of the mean distance of the three principal central asteroids (2.672519), and with $\frac{1}{5}$ of the geometrical mean between Flora and Cybele (2.683640).

Between modulus and the influent centre of solar explosive oscillation ($\frac{1}{6}$ L) there are fifteen abscissas, of which $\frac{9}{7}$ ♄ is the middle one.

Between the Saturnian abscissa and $\frac{1}{6}r$, there are fifteen abscissas, of which $\frac{1}{3}$ L is the middle one.

The abscissas representing centres of effluent or influent explosive condensation ($\frac{5}{6}$ M and $\frac{1}{6}$ L), are similarly situated with reference to the intermediate planetary belt.

No probable values can be assigned to the cardinal abscissas (α Centauri and $\frac{1}{6}$ L), which will produce deviations of the theoretical from the observed values of a higher order of magnitude than the planetary eccentricities.

Henderson's first estimate of the parallax of α Centauri was 1″.16. Maclear's observations, in 1839–40, gave ″.9128, and his more extended series, 1839–48, gave ″.9187. Norton adopts ″.913; Lockyer, ″.9187; Denison, without assigning any reason, ″.976. We may reasonably regard Norton's and Denison's estimates as the limits of probable value, and compute the logarithmic η and ζ from each estimate by the following equations.

$$\xi + 20\,\eta + 400\,\zeta = 7.686009\ (\mathrm{N}),\ \text{or}\ 7.657096\ (\mathrm{D})$$
$$\xi = \tfrac{1}{3}\,\mathrm{L} = 1.208919.$$
$$\xi - \nu\,\eta + \nu^2\,\zeta = -1.221849$$
$$\eta = 2\,\nu\,\zeta$$

Solving these equations we obtain:

$$\eta = .211401 +,\ \text{or}\ .210702 +$$
$$\zeta = .005622 +,\ \text{or}\ .005585 +$$

In the following table, C′ contains the abscissas according to Norton; C″, according to Denison; C‴, according to the actual planetary mean distances. The degree of accordance, between the parabolas which are computed from stellar and solar data and the one which is computed from planetary data, and the evidences of æthereal condensation which are furnished by the gradual lengthening of the observed abscissas, are especially noteworthy.

(V.)

	C′	C″	C‴	O
α Cent.	7.686009	7.657096	7.654826	
L×M	7.255323	7.228566	7.218310	7.215776
	6.835882	6.811207	6.801940	
	6.427687	6.405019	6.396716	
	6.030738	6.010001	6.002638	
$\frac{1}{8}$ M	5.645034	5.626153	5.619706	5.627715
	5.270576	5.273476	5.247920	
	4.907363	4.891970	4.887280	
	4.555395	4.541654	4.537786	
	4.214673	4.202470	4.199438	
$\frac{1}{3}$×$\frac{8}{9}$ ♆	3.885196	3.874475	3.872236	3.883597
$\frac{7}{8}$ ♁	3.566964	3.557651	3.556180	3.557071
$\frac{9}{7}$ ♄	3.259978	3.251999	3.251270	3.244704
$\frac{8}{9}$ ♃	2.964237	2.957515	2.957506	2.969211
$\frac{1}{3}$ ✱	2.679741	2.674204	2.674888	2,672519
$\frac{3}{4}$ ♂	2.406491	2.402063	2.403416	2.389060
$\frac{3}{5}$ ⊕	2.144486	2.141093	2.143090	2.156064
$\frac{1}{2}$ ♀	1.893726	1.891294	1.893910	1.890463
$\frac{1}{3}$×$\frac{5}{9}$ ☿	1.654212	1.652665	1.655876	1.643972
	1.425943	1.425207	1.428988	
$\frac{1}{2}$ L	1.208919	1.208919	1.213246	1.208919
	1.003140	1.003802	1.008650	
	.808607	.809856	.815200	
$\frac{1}{4}$ L	.625319	.627081	.632896	.606858
	.453276	.455477	.461738	
	.292479	.295042	.301726	
	.142927	.145779	.152860	
	.004620	.007686	.015140	
$\frac{1}{4}$	−1.877559	−1.880764	−1.888566	−1.890856
	−1.761743	−1.765013	−1.773138	
	−1.657172	−1.660432	−1.668856	
	−1.563847	−1.567023	−1.575720	
	−1.481767	−1.484783	−1.493730	
	−1.410932	−1.413714	−1.422886	
	−1.351343	−1.353816	−1.363188	
$\frac{1}{5}$	−1.303000	−1.305089	−1.314636	−1.301030
	−1.265902	−1.267532	−1.277230	
	−1.240049	−1.241146	−1.250970	
	−1.225441	−1.225931	−1.235856	
	−1.222078	−1.221886	−1.231888	
	−1.229961, &c.	−1.229011, &c.	−1.239066, &c.	

CYCLICAL RAINFALL AT SAN FRANCISCO.

By Pliny Earle Chase, Professor of Physics in Haverford College.

(*Read before the American Philosophical Society, July 19th and October 18th, 1872.*)

Although I know of no good reason for admitting that the question, whether the moon exerts an influence upon the weather, is still an open one, there is, undoubtedly, considerable uncertainty as to the value of any predictions that may be based upon such influence, liable, as it is, to local, accidental and variable disturbances, partly of a known and partly of an unknown character. On this account, I think it desirable to collect and discuss all accessible records of observations extending over a period of ten or more years, especially in the neighborhood of sea-coasts and large bodies of water, in order to find how the lunar weather-curves are modified by the forms of continental relief, the average hygrometric condition of the air, the changes of wind, and other obvious or more obscure sources of perturbation. I am willing to devote all the time I can spare from

TABLE I.

Different and non-correspondent Rainfalls at San Francisco, in Lunar and Solar periods, from July 1, 1849, to July 1, 1872. R = Total fall; N = Normal percentage of rain.

☽ DAY OR ☉ YR. ÷ 30.	LUNAR MONTHLY.							SOLAR YEARLY.						
	Nov. Dec.		Jan.		Feb. Mar.-Oct.		Yr.	1849+3n*		1850+3n		1851+3n		Av.
	R.	N.	R.	N.	R.	N.	N.	R.	N.	R.	N.	R.	N.	N.
1.....	6.67	84	8.16	124	1 26	69	97	22.85	319	16.01	287	12.19	273	297
2.....	4.93	83	12.69	128	4 74	81	97	28.41	314	14.94	264	6.12	194	267
3.....	5.55	82	6.15	115	5.07	97	94	26.26	260	11 15	242	9.84	155	226
4.....	5.61	93	6.81	105	5.88	98	92	5.20	190	14 45	238	3.90	165	198
5.....	8 52	109	9.26	99	3.18	90	96	14.98	169	13.67	227	11.97	202	194
6.....	7.73	121	5.64	84	4.49	92	104	16.81	163	9.97	200	14.57	220	189
7.....	9.74	126	2 79	75	5 65	101	107	7.67	140	9.94	171	4.97	213	169
8.....	7.96	125	7.55	86	4 55	111	108	10.08	117	8 50	140	15.32	203	147
9.....	9.00	120	7 37	97	6.78	119	107	9 11	97	4.41	108	8 04	158	117
10.....	7.03	111	7.16	94	6.51	116	103	4 38	69	5.53	84	2.58	86	78
11.....	8.12	104	6 04	79	3.86	111	97	3 25	42	3 29	62	.30	46	49
12.....	3.91	115	3.54	67	6.15	117	99	1.46	23	1.56	44	4.07	37	33
13.....	13.40	138	4.46	72	7 00	129	110	.83	11	2 72	31	.30	24	20
14.....	9.47	148	6.89	91	5.62	148	125	.10	5	.16	16	.08	8	9
15.....	9.65	137	7.84	113	9 60	172	138	.17	2	.06	5	.05	1	3
16.....	9.41	113	10.79	126	11.10	169	134	.00	1	.14	1	.00	1	1
17.....	3.87	86	8 03	128	4.96	133	115	.00	0	.00	1	.21	2	1
18.....	4 07	78	9.40	126	3 42	111	105	.05	0	.02	0	.00	1	1
19.....	7.92	86	10 06	118	8.15	110	104	.01	1	.02	0	.04	2	1
20.....	5.34	86	5.09	101	3.99	97	96	.28	2	.00	1	.00	5	2
21.....	5.17	82	6.47	92	3.67	72	85	.11	2	.04	3	.79	9	4
22.....	5.61	84	6.96	94	2.26	55	83	.04	3	.58	7	.64	12	6
23.....	7.37	80	6.36	100	1.91	57	86	.03	9	.40	8	.03	19	12
24.....	2.99	70	9 38	101	3.72	79	88	2.14	25	.61	11	2.17	37	24
25.....	4.22	71	4.84	96	6.23	87	89	2.67	52	.24	27	3.03	62	47
26.....	7.01	79	8.03	90	3.22	76	86	7.63	91	3.16	69	3.71	84	83
27.....	5.25	82	5.17	87	2.16	69	81	10.54	140	6.83	125	6.59	102	125
28.....	4.31	89	5.52	93	3.92	76	85	14.88	199	13.22	163	3.75	140	172
29.....	9.29	103	9.53	105	5.12	85	93	21.81	260	3 51	203	8.26	233	235
30.....	7.09	105	6.94	113	4.43	77	96	26.52	300	20 82	261	25.31	307	290

*1849, '52, '65, '58, '61, '64, '67, '70; 1850, '53, '56, etc., 1851, '54, '57, '60, etc.

daily duties, to such investigations; but the field is so large that I would gladly welcome the co-operation of all who may feel an interest in studies that promise new and satisfactory results as a reward for diligent labor.

The success of the Signal Service Bureau* has demonstrated the importance of careful attention to the most minute indications of possible law, and the influence of the physical geography of our continent upon the weather has been so well ascertained that we may reasonably hope for similar success from a like careful study of astronomical influences. The well-known tendency to weekly meteorological cycles has never been attributed to any more obvious or probable cause than lunar modifications of solar action, and such evidences of cyclical uniformity as have already rewarded my limited researches, encourage me to hope that much of the apparent discordance and supposed accidental irregularity, by which meteorologists are still perplexed, will be finally shown, by broad generali-

TABLE II.

Correspondent Rainfalls at San Francisco, in Lunar and Solar periods.

DAY OF YR. + 30A. ☾	LUNAR MONTHLY.							SOLAR YEARLY.						
	1849–57		1857–64		1864–72		Av.	1849–57		1857–64		1864–72		Av.
	R.	N.	R.	N.	R.	N.	N.	R.	N.	R.	N.	R.	N.	N.
1.....	5.32	88	7.15	103	6.07	99	97	16.98	266	16.77	291	17.40	328	297
2.....	5.53	89	7.76	103	6.59	98	97	14.01	233	17.71	285	17.75	282	267
3.....	6.20	94	1.87	82	9.05	101	94	12.98	184	16.63	239	22.64	253	225
4.....	6.86	94	4.22	81	5.79	98	92	5.03	159	8.43	198	10.09	232	198
5.....	4.27	89	5.50	102	6.82	98	96	9.87	187	11.60	174	19.15	217	194
6.....	6.73	91	7.63	119	8.17	103	104	20.62	218	6.76	158	13.97	188	189
7.....	6.53	97	6.83	118	6.88	109	107	8.63	200	5.20	172	8.75	140	169
8.....	6.18	98	4.44	114	9.28	113	108	11.28	164	17.47	185	5.15	104	147
9.....	5.82	94	7.71	123	7.98	108	107	7.55	135	5.62	140	8.39	83	117
10.....	5.40	92	7.28	129	7.14	93	103	7.64	104	1.54	78	3.31	54	78
11.....	6.03	94	7.18	119	4.64	83	97	2.95	72	3.62	54	.27	26	49
12.....	5.79	100	4.81	102	5.13	96	99	3.48	44	2.67	45	.94	16	33
13.....	7.22	111	4.55	99	11.21	118	110	.62	21	1.41	28	1.82	14	20
14.....	6.78	129	6.10	116	8.92	129	125	.03	7	.20	11	.11	9	9
15.....	7.61	147	3.69	139	2.67	128	138	.05	2	.05	3	.18	3	3
16.....	10.43	141	10.17	140	11.02	122	134	.12	1	.02	2	—	1	1
17.....	6.32	118	4.29	116	6.25	111	115	.00	1	.21	2	—	0	1
18.....	3.49	118	5.84	92	7.27	105	105	.02	0	.05	2	—	0	1
19.....	13.68	134	3.69	77	9.10	100	104	.01	1	.06	1	—	1	1
20.....	6.29	126	3.45	69	4.84	90	96	.00	4	.07	1	.21	2	2
21.....	5.93	101	3.83	70	6.33	82	85	.62	9	.12	1	.20	2	4
22.....	5.73	84	3.29	81	5.39	84	83	1.14	13	.03	2	.09	3	6
23.....	3.94	76	7.22	94	6.83	87	86	.00	21	.03	10	.34	5	12
24.....	4.08	82	3.55	99	6.92	85	88	3.37	35	1.15	28	.40	11	24
25.....	7.40	95	6.94	98	4.30	78	89	1.49	60	3.10	58	1.35	26	47
26.....	6.68	94	4.63	90	5.83	75	86	6.33	103	4.60	92	3.57	58	83
27.....	3.97	80	3.56	83	5.64	81	81	11.26	140	7.52	124	5.18	112	125
28.....	4.07	74	5.20	80	4.98	98	85	8.32	163	6.97	158	16.56	192	172
29.....	5.24	82	4.30	77	11.74	115	93	9.59	203	11.03	202	12.96	289	235
30.....	6.14	88	2.46	84	7.73	112	96	20.09	254	13.35	254	39.21	349	290

* Captain Toynbee's recent discussion, for the British Meteorological Committee, "of the meteorology of the part of the Atlantic lying north of 30° N., for the eleven days ending 8th February, 1870," gives very flattering evidence of the estimation in which this success is held abroad. On page 164, he says: "This paper only deals with eleven days of rather exceptional weather, when a southerly wind prevailed on our coasts. It can only be considered as a first attempt at the style of work which is needed to connect the excellent observations now being taken in America with those in Europe.

zations, to be as completely subject to ascertainable laws as are the motions of the heavenly bodies.

About a year ago, I showed, by my discussions of the Lisbon rainfall (*ante* pp. 178–190), that it is possible, under favorable circumstances, to obtain satisfactory evidence of lunar influence upon the weather, even from a comparison of the rainfall in different cycles of less than six years' average duration. My subsequent discussion of the monthly means of Tennent's San Francisco observations (*Journal of the Franklin Institute*, lxiii. 204–6), led me to hazard certain predictions relative to the tidal rains on the opposite shores of continents, and the influence of opposite winds, or of upper and lower tidal currents. Mr. Tennent has generously furnished me a copy of his daily observations on the rainfall, which so fully corroborate the first and third of those predictions, that I hope to obtain from him an equally complete record of the direction of the wind, in order to have the requisite data for similarly testing the other two. Governor Rawson W. Rawson, C. B., has also kindly consented to provide me with a transcript of observations at Barbados, a station within the belt of the trade winds, and, therefore, favorably situated for such comparisons with the San Francisco observations as may serve

TABLE III.

Normals of Rainfall in Synodic years of Jupiter.

	SAN FRANCISCO.							LISBON.	
Syn. Yr. ÷ 30.	1840–60.	1860–72.	1855–70.	Nov. Dec.	Jan. Feb.	Mar. Oct.	1849–72.	Syn. Yr. ÷ 30.	1855–70.
1	80	150	131	132	120	93	118	16	81
2	116	154	141	151	146	98	136	17	88
3	157	111	117	133	144	112	132	18	99
4	166	64	81	97	116	124	111	19	108
5	157	50	68	84	87	142	99	20	110
6	142	58	70	97	62	150	96	21	99
7	110	64	65	101	49	117	85	22	88
8	81	63	57	97	46	70	71	23	84
9	87	68	60	112	51	60	76	24	98
10	119	99	89	127	94	86	108	25	107
11	138	144	128	144	158	113	141	26	112
12	120	159	133	132	170	111	141	27	113
13	81	149	98	122	132	91	118	28	115
14	60	146	75	117	105	82	107	29	120
15	72	131	79	120	95	94	104	30	122
16	83	90	78	90	77	100	87	1	117
17	71	63	64	63	62	82	67	2	103
18	55	70	57	58	64	71	63	3	86
19	55	81	65	61	70	78	69	4	76
20	71	75	78	57	86	79	73	5	76
21	92	68	93	55	100	83	79	6	81
22	103	69	104	63	93	106	84	7	88
23	98	78	107	75	80	121	87	8	93
24	84	97	114	90	81	110	90	9	103
25	77	114	129	102	95	94	98	10	108
26	101	125	157	109	126	107	114	11	113
27	132	127	177	115	148	122	129	12	116
28	124	114	157	109	153	110	119	13	112
29	93	102	120	91	108	96	98	14	98
30	75	117	111	98	101	95	98	15	84

to strengthen the inferences which I have already published, and, perhaps, supply additional data of a novel character.

The accompanying tables and curves are constructed on the same plan as those in my previous meteorological papers. The scale and the degree of smoothing by successive means are uniform; the comparative influence of the sun, moon and Jupiter can, therefore, be readily seen at a glance. The vertical lines (0 to 7) in each set of diagrams indicate the mean hour at which the moon or planet is on the meridian, as follows:

0	12 M.	3	6 P. M.	4	12 P. M.	6	6 A. M.
1	3 P. M.	3	9 P. M.	5	3 A. M.	7	9 A. M.

The tidal influence, therefore, co-operates with the maximum direct solar influence, in the atmosphere as a whole, and especially in the upper currents, at 0 and 4; in the lower atmosphere and with the surface winds, at 2 and 6. The positions of Newton's theoretical high tides (*Principia*, B. I., Prop. 66, Cor. 20) are at 1 and 5; the low tides at 3 and 7. My theoretical low barometer is synchronous with Newton's high tide; high barometer, with low tide.

The moon's influence is most marked in the heavy rains (a); least, in the frequency of rainfall (γ). The principal maximum both in frequency and amount, is near the time of full moon, when the local atmospheric

TABLE IV.

Number of Rainfalls, and amounts of heavy rains (one inch or more), at San Francisco, on Lunar days.

Day.	NUMBER OF RAINFALLS.							AMOUNT OF HEAVY RAINS.						
	1849-57.		1857-64.		1864-72.		Av.	1849-57.		1857-64.		1864-72.		Av.
	No.	N.	No.	N.	No.	N.	N.	A.	N.	A.	N.	A.	N.	N.
1	8	71	16	108	14	91	89	3.26	118	1.73	84	2.38	75	92
2	12	76	17	102	16	96	91	2.89	104	4.10	95	.00	66	87
3	16	88	12	97	20	107	97	2.20	79	.00	66	4.21	81	77
4	17	96	15	99	21	109	101	1.04	61	.00	67	1.61	92	74
5	15	98	17	103	17	102	101	1.39	64	3.69	114	2.12	111	97
6	18	97	14	106	15	99	100	2.08	73	3.29	144	6.29	124	116
7	14	95	17	111	19	106	104	4.04	103	2.67	143	1.14	113	117
8	16	95	19	116	22	112	107	1.60	104	2.77	142	3.22	105	115
9	17	95	16	115	18	109	106	2.87	113	3.50	141	3.49	106	118
10	14	91	18	110	20	98	99	4.33	120	2.46	122	2.75	91	110
11	15	89	15	103	11	87	93	2.45	103	2.28	87	1.45	79	90
12	13	99	13	102	16	85	95	1.85	77	.00	64	1.05	116	88
13	22	117	18	110	15	93	106	1.21	78	1.80	80	7.76	181	116
14	23	130	17	121	19	105	118	2.46	123	2.50	123	6.09	207	154
15	21	131	21	126	20	117	124	4.79	175	1.18	166	.00	190	176
16	22	125	20	116	25	117	119	6.09	172	5.22	180	6.75	152	166
17	19	117	11	98	16	104	107	2.30	126	2.46	152	.00	118	131
18	16	118	14	89	14	98	102	.00	130	2.64	106	4.25	111	117
19	25	125	13	87	21	101	105	9.30	159	1.07	68	4.54	103	112
20	20	123	13	87	18	100	104	2.27	129	.00	60	.00	68	87
21	20	108	13	86	14	95	97	.00	83	2.99	86	1.60	49	72
22	12	91	13	87	18	97	92	3.63	78	1.06	117	1.62	55	80
23	13	88	13	89	19	98	92	2.20	72	5.16	121	1.34	66	83
24	17	99	14	89	15	93	94	.00	59	.00	98	3.08	66	72
25	20	105	14	81	15	90	93	2.54	67	2.02	90	1.02	48	67
26	16	101	8	72	17	93	89	2.38	75	2.79	93	.00	31	65
27	15	91	10	78	16	98	89	1.42	69	1.49	70	1.68	44	60
28	14	84	16	95	19	103	94	1.38	73	.00	41	.00	94	72
29	12	81	17	108	19	103	97	2.80	96	1.25	32	8.46	138	94
30	16	76	17	111	17	96	94	3.41	116	.00	48	1.67	119	98

oscillations from lunar influence are most antagonistic to solar action; the principal minimum, near the time of new moon, when the oscillations tend most strongly to reinforce solar action. These laws have such generality, that, at every station which I have hitherto examined, their influence is distinctly traceable.

Next in importance to the moon's modification of solar meteorologic influence, appears to be its modification of atmospheric pressure. I first called attention to the importance of this perturbation, in the third and seventh inferences of my paper on the "tidal rainfall of Philadelphia" (*ante* vol. x. p. 531), and showed that at Philadelphia it was more important than the direct and simple tidal energy. This modification, like the foregoing, is also traceable in all my previous lunar tables, and its prominence in the San Francisco curves (on lines 1 and 5, 3 and 7, in diagram γ, and on lines 5, 3 and 7, in α, β) is specially noticeable.

The second inference in the paper above quoted, that the tidal rainfall is, "like the ocean tides, more marked in low, than in high latitudes," is illustrated by diagrams β and δ. If further confirmation is desired, it may be found in the tables accompanying my previous discussions of different European, Asiatic and American observations.

My first prediction, that "the tidal rainfall will generally be found more strongly marked on the western shores of the several continents, than in the same latitudes on the eastern shores," is confirmed by the similarity in the amounts of average monthly fluctuation at San Francisco and Lisbon, and the smaller fluctuation at Philadelphia (β, δ). This difference should of course be greatly modified in the regions of the monsoons, and reversed in the trade-wind regions.

My third prediction, that "a certain degree of apparent opposition will be found to exist between the lunar influence upon the upper and lower cloud strata, dependent upon the normal difference of position in the tidal crests of deep and shallow fluid envelopes," is partially verified by the tendency to maxima at quadrature as well as at syzygy (2 and 6, 0 and 4, α, β, γ). The syzygy influence before new moon is manifested by the maximum after high barometer (7), but it is interrupted by the lunar intensification of solar action at new moon. If I succeed in obtaining such a record of the San Francisco winds as is necessary for the complete substantiation of the second, third and fourth predictions, I shall expect to find that the maxima at 2 and 6 are dependent upon the surface winds; those near 0 and 4 upon the upper atmospheric currents.

I still feel some doubt with regard to the certainty and character of Jupiter's influence upon the weather, but the amount of agreement between the curves for three independent periods of eight, seven and eight years (ζ), the resemblance between the curves at Lisbon and at San Francisco (η), when the origin of the ordinates is taken at opposition in one case and at conjunction in the other, and the character of the contrast between the lunar and Jovian curves at Lisbon (*ante*, p. 181), all tend to impress me with the belief, that at least one of the primary planets is

the source of important meteorological perturbations. I shall not be surprised if the Barbados records, when I receive them, furnish data for settling the question definitely in the affirmative. I can think of no more probable reason for the opposition between the Jovian curves at San Francisco and Lisbon, than the opposite directions of the ocean currents near the two coasts.

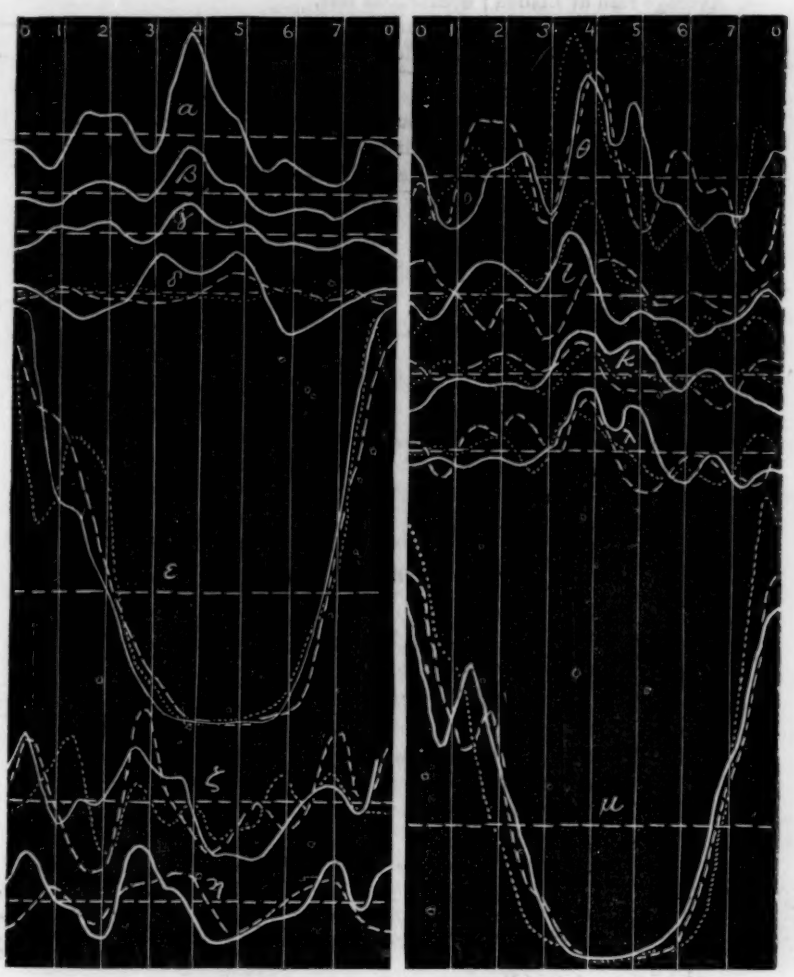
The local disturbances are evidently greater at San Francisco than at Lisbon, but in spite of them all the two sets of lunar curves at the former station, (ι, λ), each set covering three entirely distinct and independent periods, exhibit striking points of similarity, and their differences are no greater than might have reasonably been anticipated, in view of the variations in the solar curves (ε, μ). The same may be said of the monthly curves of heavy rainfall (θ) and of frequency of rain $(\varkappa)$ in different periods.

Interesting special resemblances at different stations are shown at Greenwich and Philadelphia, in Fig. 4, *ante*. vol. x., p. 535; at Philadelphia, Lisbon and San Francisco, in all the lunar curves on p. 182 and in the average annual rainfall at Philadelphia on p. 181 (Table IV.) of the present volume, as well as in the accompanying curve which depicts the frequency of rain at San Francisco from 1849 to 1857 $(\varkappa)$, continuous line,)* The maxima in my Philadelphia annual curve are somewhat more strongly marked than those in Schott's diagram (Pl. III., *Tables and results of the precipitation &c., in the U. S.*), on account of the different methods employed in computing the ordinates. Schott's were calculated from the monthly means (op. cit. p. 124), mine from means which cover only $\frac{1}{30}$ of a year, and therefore show the characteristic features of the curve more minutely, besides being better suited for comparison with the thirty ordinates of the lunar curve. My anticipations (Jour. of the Franklin Inst., lxiii, 205) that the San Francisco "daily records may probably furnish materials for more minute and detailed profitable investigation," having been thus satisfactorily realized, I now await the arrival of the Barbados records, with the expectation that their discussion will exhibit evidences of lunar, and possibly of planetary action, analogous to those which I have found at other stations, but still more prominent and more decisive than any that have ever hitherto been published. If there are any observations, extending over a long series of years, near the Gulf of Fonseca or on the Southwestern coast of Peru, I think they will furnish indications of the special importance of the lunar action on the barometric pressure, similar to those which I have found at Philadelphia, but that such indications will be more marked on the Peruvian coast, than on either coast of North America.

*Indications of a general maximum near full moon, with a diminution at the precise time of solar opposition, are to be found in the majority of the curves which I have computed. They afford, as I think, further confirmation of my third prediction. The surface tidal currents have their greatest Eastward velocity, and the upper atmosphere has its greatest Westward lagging, when the sun is on the upper and the moon on the lower meridian. The blending of currents is therefore peculiarly favorable for the precipitation of moisture, but the intense meridian heat appears to partially counteract the precipitation by re-evaporation.

Explanations of Diagrams.

The average rainfall in each figure is represented by the broken horizontal line. The lunar curves begin and end with the day of new moon; the solar curves with January 1st; the Jupiter curves, at conjunction for



San Francisco, at opposition for Lisbon. The vertical lines divide each cycle into octants. All the curves are for San Francisco, except in diagrams δ and γ_1.

Diagrams of rain in lunar months.

α. Heavy rainfall. Table IV.

β. Average rainfall. Tables I, II.

γ. Frequency of rain. Table IV.

δ. Average rain at Lisbon; continuous line.
" " Philadelphia; broken line.
" " Surrey, Eng.; dotted line.

θ. Heavy rains, Table IV.
" 1849–57; continuous line.
" 1857–64; broken line.
" 1864–72; dotted line.

ι. Average rains. Table I.
Nov.–Dec.; continuous line.
Jan.–Feb.; broken line.
Mar.–Oct.; dotted line.

κ. Frequency of rains. Table IV.
1849–57; continuous line.
1857–64; broken line.
1864–72; dotted line.

λ. Average rains. Table II.
1849–57; continuous line.
1857–64; broken line.
1864–72; dotted line.

Diagrams of annual rain.

ϵ. Table I.
1849, '52, '55, &c.; continuous line.
1850, '53, '56, &c.; broken line.
1851, '54, '57, &c.; dotted line.

μ. Table II.
1849–57; continuous line.
1857–64; broken line.
1864–72; dotted line.

Rainfall in Synodic years of Jupiter.

ζ. Table III.
Nov.–Dec.; continuous line.
Jan.–Feb.; broken line.
Mar.–Oct.; dotted line.

η. Table III.
At San Francisco; continuous line.
" Lisbon; broken line.

SAN FRANCISCO RAINFALL.

July 1st, 1849, to June 30th, 1850.

Day.	July	Aug	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	Total
1							1.01		.06				
2					1.35		.45						
3						.48							
4					.37		.39	.08					
5					1.22					.28			
6					1.12		.05	.13	.88				
7									.55				
8					1.27		1.28		.79	.05			
9				.67									
10				1.27	1.42								
11						.33							
12						1.21							
13					.76	.18	.12						
14						.10	.32						
15									.81				
16					1.15	.31							
17						.06	.16						
18						.13			.67				
19						2.08				.13			
20						.66	.17						
21						.39							
22							.07	.48	.77				
23							.95						
24							.92						
25							.52						
26						.27	.83	.34					
27								.74					
28													
29							1.10						
30				1.20									
31													
Sum				3.14	8.66	6.20	8.34	1.77	4.53	0.46			33.10

July 1st, 1850, to June 30th, 1851.

Day.	July	Aug	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	Total
1													
2						.08				.28			
3										.18			
4							.11			.06			
5							.18	.02					
6							.09	.11					
7							.22						
8										.42			
9										.06			
10													
11						.26							
12			.10										
13						.35							
14			.01										
15			.15										
16										.13			
17						.36				.06			
18								.04	.23		.58		
19					.47				.40	.04	.06		
20								.12	.08		.03		
21			.07		.10			.12	.02				
22					.04				.03				
23					.11								
24					.02			.13	.03				
25									.22				
26							.12						
27									.38				
28					.13				.22				
29					.05				.21				
30									.12				
31													
Sum			0.33		0.92	1.05	0.72	0.54	1.94	1.23	0.67		7.40

SAN FRANCISCO RAIN-FALL.

July 1st, 1851, to June 30th, 1852.

Day.	July	Aug	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	Total
1									.15				
2				.18			.07		.30				
3						.63			.60				
4			.04			.35	.03		.02				
5						.25			.80				
6								.05	1.20				
7			.99	.03					.75				
8					1.47				1.15				
9									.70				
10									.32				
11													
12													
13													
14									.10				
15									.04				
16					.37								
17								.02					
18					.03						.32		
19						.28							
20					.04	.14							
21						.06							
22						2.00				.17			
23						.55							
24						.60							
25						.20				.02			
26						.30							
27						.26			.25	.07			
28						.24	.16	.03					
29					.21	.30	.02	.04					
30						.82	1.30						
31						.12			.30				
Sum			1.03	0.21	2.12	7.10	0.58	0.14	6.68	0.26	0.32		18.44

July 1st, 1852, to June 30th, 1853.

Day.	July	Aug	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	Total
1						.82							
2						.06					.02		
3						.19	.02						
4						.21	.04						
5						.20	.69						
6							.01						
7							1.38						
8							.81		.14				
9					.02								
10							.20				.02		
11					.40		.33			.81	.25		
12											.03		
13					.30					.36			
14					.80	.52	.18		.76				
15					.25	.03			.02				
16						.20				1.85			
17					.20	3.00				1.74			
18					.62	1.40							
19						.05				.07			
20										.11	.02		
21					1.10	.21							
22						.07		.29					
23					.12	.76		.15					
24						.11		.37			.03		
25						2.54		.34					
26								.27					
27							.25		2.85		.01		
28				.80	.30	.31	.01		.02	.08			
29					1.16	1.72			.47	.35			
30					.04	.75							
31						.05							
Sum				0.80	5.31	13.20	3.92	1.42	4.86	5.37	0.38		35.26

SAN FRANCISCO RAIN-FALL.

July 1st, 1853, to June 30th, 1854.

Day.	July	Aug	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	Total
1													
2									.02				
3									.20				
4						.05		.22	.07				
5						.01		.51					
6								.16					
7													
8										.01			
9					.11	.20		.70		.01			
10				.10	.02	1.35		.52		.03			
11								.12		.20		.03	
12					.02	.11	.59	1.06	.07				
13					.08	.02	1.22		2.25				
14					.35		.27		.60				
15			.11		.29		.29		.20				
16					.22		.32						
17			.10	.02					.03			.05	
18					.14		.15						
19					.02	.10		.01	.13	.05	.02		
20						.33		.05		.43			
21								.01		.25			
22						.01	.01	1.10					
23						.02	.42	.25	.02				
24			.02				.55			.42			
25					.68		.06	.56					
26					.40			.48					
27					.04			1.26					
28						.12		.13		1.72			
29									.02				
30		.04											
31													
Sum		0.04	0.23	0.12	2.28	2.32	3.88	8.04	3.51	3.12	0.02	0.08	23.64

July 1st, 1864, to June 30th, 1865.

Day.	July	Aug	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	Total
1							1.26	.09	.54	.10			
2		.01				.02	.32		.34		.03		
3			.04			.04	.80		.16				
4				.18			.15						
5							.03		.56				
6							.08		.10				
7							.32	.05	.23				
8							.29	.24	.03				
9				.22			.17						
10			.06	.21				.22		.81			
11										.38	.05		
12									.20	.17			
13				.20					.04	.50	.30		
14									.03	1.65	1.15		
15			.05							1.05			
16										.19			
17										.10			
18					.32								
19											.10		
20											.25		
21													
22				.10	.02			.15					
23				.31				.11					
24				.05									
25				.22				.25					
26				.32				1.29					
27								.52		.05			
28								1.85					
29													
30							.19		1.21				
31						.75	.06		1.20				
Sum		0.01	0.15	2.41	0.34	0.81	3.07	4.77	4.04	5.00	1.88		23.68

SAN FRANCISCO RAINFALL.

July 1st, 1855, to June 30th, 1856.

Day.	July	Aug	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May.	June.	Total
1												.03	
2										.32			
3						.10							
4						.07		.03					
5						.17							
6						.30							
7						1.15							
8							.38						
9							1.05			.21			
10					.02	.23	1.04			.58			
11							.72			1.04			
12										.17			
13					.05	.22							
14						.05	.67		1.02				
15						.20	.32						
16													
17													
18													
19						.24		.12			.28		
20						.38	.55	.33					
21					.10	.75	.10				.08		
22					.21	.10	1.14				.40		
23					.13		.47						
24													
25													
26						.80							
27						1.00							
28					.08		1.22	.02	.05				
29							1.08		.10				
30					.08		.66		.20	.02			
31									.23				
Sum					0.67	5.76	9.40	0.50	1.60	2.94	0.76	0.03	21.66

July 1st, 1856, to June 30th, 1857.

Day.	July	Aug	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May.	June.	Total
1									.13				
2							.15						
3							.44						
4							.21	.37					
5							.12	.43					
6											.01		
7				.31		.15							
8									.03				
9													
10			.02					.07			.02		
11			.05			.28		.05					
12						.21		.31					
13								.53					
14				.01		.04		1.27					
15					.16	.03		1.30					
16				.02	.06		.24	.84					
17				.03	.20	.45	1.19						
18							.10	.04					
19								.04					
20					.90								
21					.17				.18				
22					.70				.03				
23						.20							
24				.08	.2[2]	.24		.87	.29				
25								1.17					
26	.02							.85					
27						.20		.45	.36				
28					.06				.47				
29					.32	.08						.12	
30						.48					.02		
31						1.39			.13		.05		
Sum	0.02	*	0.07	0.45	2.79	3.75	2.45	8.59	1.62		0.10	0.12	19.96

SAN FRANCISCO RAINFALL.

July 1st, 1857, to June 30th, 1858.

Day.	July	Aug	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	Total
1										.42			
2					.10								
3					.35								
4					.88	.15				.27			
5					.31	.20							
6				.17		.26							
7				.44			.03	.08		.72			
8				.32						.14			
9						.22							
10		.03				.43	.25						
11						1.68	.37						
12						.22	.40		.52				
13							.51	.05					
14								.30					
15								.44					
16								.41	.17				
17								.25	.04				
18												.05	
19								.20			.23		
20							.83	.15			.06		
21							.55				.05		
22							1.42						
23													
24					.15	.98			.40				
25					.49								
26					.14				.37				
27					.17				1.80				
28		.02			.04				.60				
29					.33				1.65				
30					.05								
31													
Sum		0.05		0.93	3.01	4.14	4.36	1.83	5.55	1.55	0.34	0.05	21.81

July 1st, 1858, to June 30th, 1859.

Day.	July	Aug	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	Total
1								.24			.38		
2											1.07		
3									.21				
4						.07			.29				
5						.27							
6								.16					
7								.08	.20				
8								.54	.20	.13			
9								.11					
10						1.80		.12		.03			
11						1.02		.62		.02			
12						.08		.78					
13								.14					
14		.04				.17							
15								.34					
16								.14					
17						.06		1.04					
18													
19					.27								
20				.30	.20				.15				
21				2.06	.14	.05			1.07				
22					.04				.73		.06		
23				.12		.42		.13			.04		
24				.26		.64		.34					
25								.12					
26		.12			.04	.28		.08	.03				
27	.02					1.04	.05	1.11	.04				
28	.03					.20	.21	.23					
29									.03				
30							.17		.07				
31						.04	.85			.09			
Sum	0.05	0.16		2.74	0.69	6.14	1.28	6.32	3.02	0.27	1.55		22.22

SAN FRANCISCO RAINFALL.

July 1st, 1859, to June 30th, 1860.

Day.	July	Aug	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May.	June.	Total
1							.08		.40	.49	.12		
2					.06		.07				.62		
3		.02			.36		.24			.95	.43		
4					.90	.04				1.32	.12		
5					.84		.21		.37	.55			
6							.56		.03	.06		.07	
7							.22	.60		.04			
8							.23			.44			
9					.02								
10					.80				.13				
11					.13						.17		
12								.10	.03				
13								.43					
14													
15			.03						.10				
16								.04	.17				
17					.07			.17					
18								.14			.39		
19										.09			
20													
21					.14								
22					.23		.03		.39		.35		
23				.05	.25	.21			.11		.28		
24					.31	.63					.04		
25					1.73	.38					.28		
26					.51	.21					.06		
27						.10			.05				
28									.00			.02	
29								.12	.62				
30													
31					.08				.09				
Sum		0.02	0.03	0.05	7.28	1.57	1.64	1.00	3.99	3.14	2.86	0.09	22.27

July 1st, 1860, to June 30th, 1861.

Day.	July	Aug	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May.	June.	Total
1						.02	.21						
2										.16			
3				.01						.15	.10		
4				.12			1.03			.03			
5				.08			.49					.04	
6				.01		.04	.23						
7						.13		.06					
8													
9								.12					
10	.21					.02		.14					
11					.21	.13		2.02					
12					.35	.07						.04	
13													
14						.37							
15						.23	.03						
16						.78							
17				.04		.04							
18						.26							
19				.17		.27	.14						
20				.08		.21	.22				.65		
21						.15		.21			.25		
22						.58							
23						1.03	.12	.08	.79				
24				.12		.77		.10	.07	.17			
25						.63		.99	.04				
26						.13			2.53				
27				.03		.07			.40				
28				.11	.02				.04				
29				.04					.18				
30				.10					.03				
31						.23							
Sum	0.21			0.91	0.58	6.16	2.47	3.72	4 08	0.51	1 00	0.08	19.72

SAN FRANCISCO RAIN-FALL.

July 1st, 1861, to June 30th, 1862.

Day.	July	Aug	Sept	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May.	June.	Total
1						.05				.11	.02		
2			.02					.79		.13	.56		
3						.07				.07			
4													
5							2.67	.04		.01			
6						1.02	1.49						
7						.29			.02				
8						1.65	1.35			.09			
9						.18	3.50		.01	.17			
10					.27		2.46		.47				
11							1.25		.57	.01	.03	.05	
12					.74				.18		.11		
13					.29		0.22			.02			
14					.05				.25	.12			
15					.08		.49		.11				
16					.39	.01	2.46		.12				
17					.22		2.64						
18							.52				.02		
19					.56		.72	.44					
20							1.69						
21							.55	2.09					
22						.03	1.00	.80					
23						1.06		.84					
24						.56		.33					
25								1.49					
26					.48	2.02		.38					
27					.60	.23	.04	.33					
28						.17			.07				
29					.08	.70	.76		.20				
30					.34	1.25	.55		.20				
31						.25							
Sum			0.02		4.10	9.54	24.36	7.53	2.20	0.73	0.74	0.05	49.27

July 1st, 1862, to June 30th, 1863.

Day.	July	Aug	Sept	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May.	June.	Total
1							.27						
2													
3							.12						
4							.71						
5							.46	.44					
6					.11			.16					
7					.02				.05				
8								.11		.19			
9						.19							
10					.02								
11							.15	.16					
12								.71					
13										.12			
14								.11		.10			
15										.38			
16								.40		.32			
17								.58	.16				
18						.12		.47	.19		.14		
19						.05	.74		.11		.09		
20						.32	.36		.56	.24			
21						1.01		.05		.10			
22						.17	.76						
23						.14	.06						
24									.04				
25									.07				
26									.88	.12			
27										.04			
28													
29				.02									
30				.38		.22							
31						.13							
Sum				0.40	0.15	2.35	3.63	3.19	2.06	1.61	0.23		13.62

SAN FRANCISCO RAIN-FALL.

July 1st, 1863, to June 30th, 1864.

Day.	July	Aug	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May.	June.	Total
1										.91			
2						.33	.12						
3										.35			
4										.23			
5							.39						
6													
7													
8													
9						.15							
10						.05					.01		
11					.05	.02					.10		
12					.07								
13						.27					.01		
14					.87						.11		
15					.92		.14		.03				
16					.64								
17									.04		.55		
18									.89				
19													
20			.03						.02				
21						.37							
22													
23						.52							
24						.09							
25													
26										.08			
27									.06				
28									.14				
29							.37		.09				
30									.07				
31							.81		.18				
Sum			0.03		2,55	1,80	1.83		1.52	1.57	0.78		10.08

July 1st, 1864, to June 30th 1865.

Day.	July	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May.	June.	Total
1							.51						
2						.33							
3						.13			.21				
4						.03			.38				
5						.04							
6						.92	.08			.21			
7			.01							.02			
8													
9										.11			
10						.01							
11						1.05							
12						2.56			.07				
13						.99		.30					
14								.10					
15					.14	.04		.08					
16						.27		.12					
17													
18							.07	.40			.45		
19								.24	.09		.18		
20													
21													
22		.11											
23		.03			.05	.38							
24		.07		.02			.07						
25					.48	.47	.88						
26				.05	3.98	.81	.38						
27				.06	.42		.74	.05					
28					.44	.02	.91	.05					
29					.50	.04							
30					.67	.30							
31						.52	1.50						
Sum		0.21	0.01	0.13	6.68	8.91	5.14	1.34	0.74	0.94	0.63		24.73

SAN FRANCISCO RAINFALL.

July 1st, 1865, to June 30th, 1866.

Day.	July	Aug	Sept	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	Total
1						.01		.36					
2						.01		.16					
3								.43					
4								.19					
5							.30	.22	.02				
6							.19		.21				
7				.03			.41						
8				.07		.04	1.51		.66			.04	
9								.16	.30				
10							.40						
11							.46						
12							.60	.06					
13					.18	.06	.60						
14					.37								
15													
16					.07		.23						
17					1.03		2.17		.02				
18					.27				.21				
19					.06		.11		.41				
20					.06		2.22		.23				
21					.63		1.14				.06		
22					1.12	.04	.15				.22		
23						.15	.08						
24			.06			.25	.31						
25				.01					.36		1.05		
26			.18			.02					.01		
27								.07			.05		
28								.47			.07		
29									.02	.12			
30				.15	.40				.11				
31									.49				
Sum			0.24	0.26	4.19	0.58	10.88	2.12	3.04	0.12	1.46	0.04	22.93

July 1st, 1866 to June 30th, 1867.

Day.	July	Aug	Sept	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	Total
1						.53			.17	.32			
2					.68		.03		.16	.15			
3					.25	.13							
4					.14		.18						
5					.31		.65			.40			
6			.07				.51			.15			
7													
8					.07				.40				
9										.02			
10										.67			
11						.53	.11			.50			
12						.01	.75			.15			
13													
14							.05						
15			.04			.63							
16					.26	.43							
17									.16				
18						.95		.49					
19					.02	4.28	.23	.15					
20						3.62	.18	2.12					
21						.64	.58	2.22	.34				
22						.31	.17	.30					
23							.40						
24					.38	.06	.35						
25					.29	.71		.08					
26					.28	.56	.78	.14					
27						.32		1.02					
28						.63		.68					
29					.14	.40							
30					.53	.42	.19		.05				
31									.30				
Sum			0.11		3.35	15.16	5.16	7.20	1.58	2.36			34.92

SAN FRANCISCO RAINFALL.

July 1st, 1867, to June 30th, 1868.

Day.	July	Aug	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May.	June.	Total
1						.02	.93		.56			.01	
2						.18	.33		.20				
3							.12		1.55	.10			
4							.15		.55				
5				.20	.62								
6					.75								
7						.15		.06		.20			
8						.55	.66						
9						.24				.38			
10						.33				.30			
11							.12		.19	.70			
12							.87			.47	.01	.05	
13							.43		.56	.06			
14			.04						.44	.04			
15									.14				
16						.04							
17						1.62	.12						
18						.69	.41				.02		
19					.79		.43						
20						.48	.64		.16				
21					.75	.84		.64	1.05				
22						1.68	1.08	.54	.90			.08	
23						.72	.99	.14				.09	
24					.44	.08	.84	.86					
25					.06	1.35	.36	.69					
26							1.02	1.61					
27								1.02					
28								.37					
29						.06		.20					
30						.21				.06			
31						1.45							
Sum			0.04	0.20	3.41	10.69	9.50	6.13	6.30	2.31	0.03	0.23	38.84

July 1st, 1868, to June 30th, 1869.

Day.	July	Aug	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May.	June.	Total
1				.06			1.28						
2				.08			.53	.44					
3								.30					
4				.01	05	.01							
5													
6													
7							.10	.20		.28			
8								.82					
9								.32					
10							.01	1.67					
11							.07	.15					
12									.05				
13									.08				
14							.08		.10			.02	
15									.14				
16									.63	.45			
17						.05			.55	.69			
18					.30	.55			.18	.68			
19					.64				.48	.09	.06		
20									.67				
21						.07							
22						.18	.15				.02		
23						1.20	1.45						
24						.29	.19		.01				
25					.08	.47	.25						
26						.92	.20		.10				
27							.15						
28							.54						
29					.11	.18	1.10		.15				
30						.32	.25						
31						.10							
Sum				0.15	1.18	4.34	6.35	3.90	3.14	2.19	0.08	0.02	21.35

SAN FRANCISCO RAINFALL.

July 1st, 1869 to June 30th, 1870.

Day.	July	Aug	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	Total
1			.12										
2										.48			
3										.21	.02		
4										.09			
5													
6					.14								
7						.41							
8						1.10				.01			
9								.41					
10					.65	.13	.09	.02	.02				
11					.20	.14	.11		.14	.16			
12					.05		.14	.14	.18	.58			
13					.05		.35						
14							.53	.11					
15							.31	.34					
16									.22				
17									1.05				
18				.02			.76						
19				.17			1.03	.08			.18		
20				.36			.27	.86					
21				.74				.25					
22						.22	.30	.90					
23						.46		1.57	.27				
24						.51		.10					
25						1.34							
26													
27					.04								
28					.06								
29													
30									.01				
31													
Sum			0.12	1.29	1.19	4.31	3.89	4.78	2.00	1.53	0.20		19.31

July 1st, 1870, to June 30th, 1871.

Day.	July	Aug	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	June.	Total
1						.59							
2						.57							
3										.06			
4					.01			.37					
5						1.42				1.47			
6					.02	.12		.12	.26				
7					.22	.32							
8								.02					
9							.42						
10							.32						
11													
12									.01				
13						.09		.14					
14						.27		.13					
15								.67			.04		
16									.08	.29			
17							.21		.08	.11			
18							.78						
19									.36				
20								.72					
21								1.02					
22							.28	.28	.13				
23							.62	.29	.37				
24													
25													
26											.01		
27													
28							.44				.16		
29					.18								
30			.03										
31													
Sum			0.03		0.43	3.38	3.07	3.76	1.29	1.93	0.21		14.10

SAN FRANCISCO RAINFALL.

July 1st, 1871, to June 30th, 1872.

Day.	July	Aug	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	May.	June.	Total
1								.02	.14				
2						.16		.06					
3					.19		.86	.14					
4								.01	.17			.01	
5							.17		.50				
6							.10						
7							.18	.33					
8							2.35	.89	.11				
9					.03		.34	.82	.06				
10								.21					
11							.11	.28	.33				
12							.02		.13	.05			
13					.02		.02						
14					.18			.10					
15					.22			.24		.35			
16								.29		.43			
17			.01			.63		.28		.08			
18						3.22		.02					
19						3.49				.01			
20						.62							
21						.93		.61					
22						.32		.44	.02				
23						3.48		.76					
24				.02	.35			.41			.03		
25								.16					
26					1.67	.15				.16			
27			.02	.09	.13	.74		.90	.04	.02			
28					.93	.23							
29						1.04							
30						.13					.02		
31						1.60	.07		.14		.11		
Sum			0.03	0.11	3.72	16.74	4.22	6.97	1.64	1.10	0.16	0.01	34.70

ON THE DENTITION OF METALOPHODON.

By Edward D. Cope.

(*Read before the American Philosophical Society, September* 20, 1872.)

This discovery of a second species allied to *Bathmodon*, Cope, represented by more complete remains of dentition than that on which that genus was originally established (*B. radians*), renders it possible to enlarge our knowledge of its characters.

It may be premised that the new species may belong to the group *Loxolophodon*, and, as its characters differ from those of the large species *Eobasileus cornutus, furcatus* and *pressicornis*, I must retain the last named genus with characters ascribed in my last paper to the former, and withdraw the species from the former, to which I at that time referred them. It appears that this name, used first for a section of *Bathmodon*, was, perhaps, based on mandibular teeth alone, which in *Metalophodon*, differ remarkably from the maxillaries. The cranium of the new species to be described was so decayed as to be irrecoverable, but the teeth obtained were in place, and in close proximity, so that there can be no reasonable doubt that they belong to the same animal.

The species differ considerably from the *B. radians*. The most prominent are: first, the failure of the lateral or straight limbs of the

crescent of the tooth-crown to meet at the apex, in the molars proper; second, the presence of two lobed premolars only, the three lobed found n *Bathmodon* not being represented in any series. The first character appears to me to be of generic importance, hence the name applied to it at the head of this article. It may yet prove to be *Loxolophodon*, as no generic character distinguishes the inferior molars of the two. It remains however, to determine whether that name applies to *Bathmodon*, or a genus different from it, as the present. In the meantime the new species may be called *Metalophodon armatus*. It is as large as the Indian *Rhinoceros*, or perhaps larger.

The *incisors* are well developed, those of the premaxillary subequal in size. The crown has a convex cutting edge and flat inner face. The outer face is convex. In some the inner face is more concave, and is bounded by a cingulum next the root.

The *premolars* present a single external crescent of acuminate outline, and a smaller, more transverse one, within. A cingulum bounds the crown fore and aft, but is wanting at both base and apex of the triangular base. In the more posterior the crescent is more open, and the crown less transverse.

Tho *molars* present an increase in transverse extent of the external crescent, and the interior one is wanting. In the posterior two the anterior ridge curves round at the apex, but is separated by a considerable interruption from the posterior. The latter is shortened, and terminates externally in a conic tubercle, which approaches the outer extremity of the anterior ridge. In the last molar the posterior ridge is shorter, nearly straight, and terminating in a cone at each extremity.

The *canine* is damaged, but was of large size, amounting in one or the other of the jaws to a tusk. The probably superior is compressed, with acute edges. The inner face gently convex, the outer more strongly so, with an acute ridge on its anterior convexity, inclosing an open groove, with the interior cutting edge. This surface of the dentine when exposed has a transversely wrinkled character, but no trace of engine-turning in the fractures.

In the *mandible*, premolar and molar teeth are recognizable; the character of the incisors remaining uncertain. As usual in ungulates, they possess a relatively smaller transverse diameter than do the corresponding teeth of the maxillary. They change very materially in form from the front to the terminus of the series, and in connection with the superior molars, are very instructive as to the genetic connection of different types of dentition.

The pecularity of the *premolars* consists in the fact that besides the single external crescent exhibited by those of the upper jaw, they have a rudimental second one in the position it should occupy in corresponding teeth of *Palæosyops*. The inner border of the crown is convex, and extends from apex to apex of the crescents. There are no cingula to these teeth. The rudimental crescent diminishes anteriorly, its angle

becoming first obtuse, and then disappearing. Posteriorly the reverse process takes place, and proportions increase. But in the last *molars* they do not assume the proportions seen in *Palæotherium* and allied forms. They increase in the elevation of corresponding ridges of the crescents, and decrease in the others, so that the resultant form is nearly like that of *Dinotherium* or perhaps *Lophiodon*. The outer ridge of one crescent appears as a cingulum, which sinks to the base of the crown from the apex. This is rudimental in the genera just mentioned. The corresponding bounding ridge of the other crescent is reduced to a rudiment extending diagonally across the valley between the remaining crests, as is seen in not a few genera of the Eocene.

We have thus an explanation of the heretofore obscure question as to the origin of the crescent-bearing tooth of the Artiodactyles. From the two crested type of *Tapirus*, the two-angled form developes itself by the growth of the cingulum and diagonal crest just described. This is seen completed in *Palæosyops*. The elevation of the ridges and deepening of the intervening valleys, would result in the ordinary Ruminant type. The same process increasing transverse crests only, derives the *Mastodont* from the *Tapiroid* form, and the deepening of the valleys of this, again results in *Elephas*.

In comparison with *Bathmodon semicinctus*, Cope, the crowns of the premolars are of similar size, but considerably less elevated.

The measurements cannot be given with exactitude, but are approximately as follows: Superior incisor crown, width. 75 inch; elevation .60 inch. Canine 1.25 inches from apex, inner face .75 inch. Premolar length. 76, width 1.1 inch. Molar length crown 1.1 inch, width 1.25 inch. Inferior premolar, length of crown 1 inch, width .75 inch. Posterior molar, length 1.30 inch, width .9 inch. The crests of the last mentioned are quite elevated, one more than the other; the lower with a strong cingulum at the base, which rises to what is homologous with the base of a triangle, or outwards; none on the inner aspect of the base of the crown. The cingula of the superior molars are only anterior and posterior.

This large ungulate was found in a stratum below those of the Green River Group of Hayden, or in the lower beds of that series, near Black Buttes, Wyoming. Obtained by the Geological Survey under direction of Dr. F. V. Hayden.

In a line of banks or low bluffs, immediately below that in which the *Metalophodon* was found, dermal scutes of a small crocodilian are abundant. The discovery of the greater part of a cranium of one of these enables me to point out the existence of a species of Alligator of still smaller size than the smallest of the Caimans at present inhabiting South America. This species, which I call ALLIGATOR HETERODON, possess several peculiarities. The anterior and posterior teeth differ exceedingly in shape; the former are flattened, sharp-edged, and slightly incurved; the edges not serrate. Those of the premaxillary bone are subequal in size, while one behind the middle of the maxillary is larger

than the rest. The posterior teeth have short, very obtuse crowns with elliptic fore and aft outline. They resemble some forms seen in Pycnodont fishes, and are closely striate to a line on the apex. The upper surface of the cranium is pitted, the frontal and parietal bones, with large, deep, and closely placed concavities. The former is perfectly plane, and the latter is wide. The squamosal arch is also wide, and the crotaphite foramina are large and open. The dermal scuta are very large for the size of the animal, and were not united by suture. They are keelless, and deeply pitted, with smooth margins.

The vertebral centra found with other specimens are round. The coössified neural arches indicate the adult age of the animal.

MEASUREMENTS.

	M.
Height crown premaxillary tooth	.004
Width " " at base	.0035
Long diameter crown of a maxillary	.005
Short " " "	.0035
Width parietal	.009
Width frontal { posterior	.020
Width frontal { interorbital	.010
Width molar below eye	.008

The variation in the form of the teeth is a slight exaggeration of that seen in the dentition of various species of crocodilians.

Stated Meeting, Oct. 4th, 1872.

Present, 20 members.

Vice-President, Mr. Fraley, in the chair.

A letter, accepting membership, was received from the Rev. S. H. Nichols, dated 415 South Fifteenth Street, Philadelphia, September 26th, 1872.

An engraved portrait of William Smith, D.D., first Provost of the College of Philadelphia, was presented by Mr. Horace W. Smith.

A circular letter, announcing the death of Signor Felice Finzi, dated Firenze, 4th September, 1872, was received from his relatives.

A letter of envoy and acknowledgment (Proc. 81 to 85) was received from the Geological Society of St. Petersburg.

Donations for the library were received from the Revue Politique; the Meteorological Committee of the London R.

S.; London Nature, Old and New; American Academy of Sciences; American Oriental Society; Prof. O. C. Marsh; M. Alph. Loubat; the Franklin Institute; Academy of Natural Sciences; Journal of Pharmacy and Penn Monthly, of Philadelphia, and the Petroleum Monthly.

An obituary notice of Mr. Eckfeldt, by Mr. Dubois, was read by appointment by Mr. Patterson.

The death of Mr. Ralph Ingersoll, of Connecticut, a member of this Society, August 25th, aged 83, was announced by the Secretary.

Mr. Lyman offered for publication in the Transactions, a paper and map of his researches into the geology of the Staley's Creek Coal and Iron region of Virginia, which he described summarily. On motion, they were referred to a committee, consisting of Prof. J. F. Frazer, Mr. Lesley, and Professor P. Frazer, Jr.

Pending nominations, Nos. 697 to 702, were read, and new nominations, Nos. 703 to 705.

On motion, the West Virginia University, at Morgantown, was ordered to be placed on the list of correspondents to receive the Proceedings.

On motion of Mr. Price, it was resolved that the Curators be authorized to deposit the arm-chair, now in posession of the Society, one of those used by members of the Continental Congress, in the Hall of Independence: provided the authorities of the City of Philadelphia will agree, by Ordinance, to return it to the Society, whenever so requested by it.

Dr. Elder asked and received permission to deposit in the Hall of the Society a chair, left in his care by Mr. Washington, who fell at Vicksburg; said chair having been occupied by Judge Bushrod Washington, presiding in the Circuit Court of the United States.

And the meeting was adjourned.

Obituary Notice of Mr. Jacob R. Eckfeldt.

By Mr. Dubois.

(*Read before the American Philosophical Society, Oct. 4th*, 1872.)

Jacob R. Eckfeldt, late Assayer of the Mint, was the son of Adam and Margaretta Eckfeldt, and was born in Philadelphia March —, 1803. He was, therefore, in his seventieth year, at the time of decease, August 9th, 1872.

He early developed a studious mind, and a fondness for solid information, especially in the domains of physical and mechanical science. He was mainly educated at the classical academy of Dr. Wylie and Mr. Engles, celebrated in those days.

When he was grown up, and old enough to engage in business, he was placed in Mr. Greiner's Cotton Mill, at Trenton, as a subordinate manager, where he continued for several years, until that enterprise proved unsuccessful. After that, he was employed by Mr. Cloud, then Melter and Refiner of the Mint, to attend to the parting room.

In the Spring of 1832, Mr. John Richardson, who had been Assayer about one year, and did not find the employment congenial to his tastes (withal a man of good parts and highly esteemed), informed Mr. Eckfeldt that he intended to resign, and wished him to prepare to take the place. Mr. E. shrank from this responsibility and declined. But some of his friends who had influence with President Jackson presented his name with a strong recommendation and he was appointed without being asked as to his party preferences. This occurred on the 30th of April, 1832. He has therefore held the office over forty years.

When he entered upon the work, he had to encounter some embarrassments. The apparatus was old-fashioned, and not calculated for nice results. The silver assay had been well performed, without going to a close figure, for many years; but gold was little known in the country or at the Mint, and it is not surprising that its assay was incorrectly performed. Add to this, there was the coarse and cumbrous nomenclature, brought from the old country, of carats and grains for gold fineness, and so many grains to the pound for silver fineness.

Close upon all this, that is to say, in June, 1834, came the celebrated reduction in the standards of our gold coin, one of the chief measures of the Jackson administration. This changed gold from a curiosity to a currency; bullion and foreign coin flowed to the mint, and accuracy of assay was more than ever needful. Mr. Eckfeldt was equal to the emergency; and resolutely introduced reforms, which, at first, made the older officers stand in doubt. At this crisis he was taken down with small-pox; and shortly after, his valued foreman also. Both, however, recovered.

In those days, about the time the new mint edifice on Chestnut street was finishing, Mr. Peale was sent to London and Paris to observe the methods of assaying and refining, and to procure a new apparatus. We were thus supplied with French beams, weights, and cupel furnaces, and

with the appliances of Gay-Lussac's humid assay, and the printed details of the process. Soon after, Mr. Saxton, famous for his skill in constructing balances and other delicate instruments, returned from a long schooling in that line in London, and was employed in the Mint. Thus furnished, Mr. Eckfeldt felt himself "set up," and able to compete with the foreign assayers, and if he was ever more precise, it was because he disregarded certain allowances which had become a time-honored custom.

A large importation of fine gold bars from France, known as the French Indemnity, and which came because President Jackson declared he "would submit to nothing that was wrong," gave a fine opportunity for testing and comparing foreign assays; and it was generally found that these bars were somewhat below the alleged fineness. Still the deficit was inconsiderable; but it is characteristic of French gold coin, as well as bars.

It is not surprising, that he felt at first the inconvenience of passing from one form of nomenclature to another, though to a better one. A friend remarks, "I recall conversations with Mr. Eckfeldt, showing how seriously he felt the revolution. He would *think* in carats, and *report* in decimals. And I often recur to this as illustrating the kind of difficulties which would arise in case of a decimaliding of weights and measures."

For some years prior to 1842, Mr. Eckfeldt and his assistant, in addition to their ordinary duties, engaged in the preparation of an original and comprehensive work on the Coins of all Nations; on the Varieties of Gold and Silver Bullion; on Counterfeit Coins, and on other subjects related thereto. This was published in 1842, and has long been regarded as a standard authority. In 1850, they issued a supplementary smaller work, and again in 1852.

As the United States increased in commerce, wealth and population, the Mint of course increased in work. In particular, Mexican dollars came in great quantities for recoinage. Not only were our vaults full, but our entries and corridors were at times crowded with rows of kegs. Every day, for years, we had the constant task of sixteen melts of silver ingots to melt and assay; and it was a great advantage and satisfaction to be supplied with the *humid* apparatus.

The success of gold mining in our Southern States, and the increasing commerce of New Orleans, gave rise to the establishment of three branch mints at the South, in 1837; and it devolved upon Mr. Eckfeldt to become schoolmaster, and educate the three assayers appointed for those places. The same had to be done again at a later date for other mints and assay offices.

In December, 1848, came the first lot of gold grains from California; and with the opening of the next year the tide set in most powerfully. I shall not here speak of this great turning-point in metallic currency any further than as it affected the mint, or rather the labor which it laid upon Mr. Eckfeldt and his department. As is well known, the lots were numerous, and the aggregate amount was enormous. Instead of making

gold assays by dozens, we had to go through with hundreds, every day following the arrival of each steamer. We procured young men as operators in the weigh-room and additional workmen in the laboratory; and in spite of all the help we were all overworked. Here let me say that the persons who have been educated by Mr. Eckfeldt to this profession have done credit to the selection that was made, not only by skill, diligence, and good character while here, but wherever they are now scattered to other mints and assay offices, or to different pursuits. No doubt they receive with profound sorrow the tidings of the decease of their instructor.

The gold pressure continued for about five years, when it was relieved by the creation of a government assay office in New York, and a branch mint at San Francisco. But directly sequent to this came the change of standard in silver coin, causing an immense recoinage in small pieces. Thus our daily assays continued to count by hundreds. This lasted for some years. When it began to slacken off, a law was passed for calling in the large copper coins and issuing in their stead pieces of copper-nickel alloy of much smaller size.

The analysis of Nickel alloys was not well laid down in the books, and the European or other assays which came with purchased lots showed an incorrect determination. Mr. Eckfeldt was therefore obliged to study out and perfect this assay, which is more tedious and laborious, though of less consequence, than the assay of the precious metals.

But it was his habit to be as scrupulous in minor matters as in major; and after the routine was well settled it went on with the same clockwork regularity as the other branches of assaying. I need not say that this nickel coinage imposed another heavy pressure upon the mint for years.

After this came the substitution of the Bronze alloy; and this called for another process of assay, and brought us a great deal of work.

I thus hastily review this sequence of gold, silver, nickel, and bronze, not only as an interesting part of Mint History, but to show the varied and abundant services of the untiring, energetic Principal Assayer, and the masterly skill with which he met every obligation.

His nervous system, naturally not one of repose, was a good deal impaired by the cares and labors of the first period just reviewed, and in 1853 he had to seek relief by travelling southward. This had a beneficial effect, but from that time onward, although he continued to be very active, there was a marked deterioration of health. Early in the Summer of 1870 he had a serious spell of illness, in which an affection of the heart was developed. This, by degrees, culminated in a dropsical state of the system, and on the 26th day of April, 1872, he was at the mint for the last time.

I would not undertake to define his various traits of character, professional or personal; but a few remarks in that way may be in place.

In every character we may observe apparent or real opposites; and in respect to Mr. Eckfeldt, there were two notable instances.

First, he was not ready in the use of language. There was wealth of thought, but not freedom of expression. This was always to some extent his embarrassment. If, with his stores of general and scientific knowledge, he had also possessed the powers of a speaker or writer, he would have made a larger impression. And yet he was communicative and sociable habitually. In his daily rides in the car, part-way to his house in the country, he was glad to find those with whom he could converse along the road. This is only an instance of his social temper, at home and abroad.

Again, it cannot be said that he made what might be considered inventions or discoveries of new processes. Inventors are really few; and they are generally much indebted to those who come after them and improve upon them. And yet his skill and success as an Assayer and Analyst largely consisted in his power of finding out what was defective or erroneous, and in applying the proper remedy. It often seemed that what was a puzzle to others was to him a matter of quick insight.

In the assays of certain complex alloys, and of low grades of gold and silver, he contrived various methods which are not in print, but which are of great use in the daily manipulations.

And here I may state that he not only introduced great accuracy and precision in the assays, but carried special investigations to a delicacy almost incredible. This was partly to be credited to the progressive improvement in assay balances, by which, after discarding the old silken cords, we had Deleuil's beam with steel stirrups; then Saxton's palladium beam with drop supports, then the more sensitive and more complicated Oertling, and at last the simple and complete Becker. So that, instead of weighing to a thousandth of the normal weight as formerly, we now have indications to the tenth of a thousandth, or even less.

If, therefore, curiosity or the promotion of science led him to inquire how much or rather how little silver there was in a certain kind of lead or gold in an ordinary brick or pile of gravel, he would begin with a pretty large sample, then carefully concentrate the precious metals, if any, and finally bring his visible speck to the balance, to determine a proportion in millionth parts. Only lately he found in a bar of Spanish lead, which is remarkably free from silver, the amount of one-third of an ounce of silver, in a ton of lead,—and much interest was excited by a publication some years ago, both in this country and across the Atlantic, of his experiment upon the brick-clay which underlies our city. Taking two samples from the center of the town and the suburbs he found they contained gold at the rate of nearly 12 grains (say fifty cents) to the ton of clay in its ordinary moisture. Other experiments went to prove the very general diffusion of gold, in infinitesimal proportions.

Some analysts, through want of exactitude, or for the pleasure of making a sensation, may produce very curious results; but Mr. Eckfeldt was conscientious, I may say, nervously scrupulous, about stating anything he was not sure of. Partly for that reason, partly for the very love

of work, he was laborious to a fault, all his life long. It can hardly be said to have shortened his days, for he well nigh attained to the limit and double the average of human life.

Although he did not take the same interest in rare and curious coins that his father did, and was not a student of numismatics, yet he had a cultivated taste in this way, and a fine appreciation of the principles and art by which a perfect piece is made.

He was baptized and confirmed in the Lutheran Church, and afterwards united with the Presbyterian Church in Ninth St., near his father's house. He was soon elected to the Eldership, and he was no honorary or nominal Elder, but fulfilled the duties of the office, and was valued for his solid judgment. He was moreover active in the Sunday-school, the Bible Society, and other modes of benevolent operation. Some years after he became a member and elder in the Arch street Church; and since his residence in the country has belonged to Marple Church, in Delaware county.

He was elected a member of this Society in January, 1843.

He was a man of feeling, as well as of principle; affectionate, as well as exact. He made new friends and cherished old ones. This disposition even increased with his years, and was not diminished when his mind had lost its power. There were many proofs of this, which may not here be repeated. But the writer may be excused for stating an instance in his own experience. As he stood by the bedside, one of the family asked Mr. Eckfeldt if he knew who it was. The very question started an agitation which was almost convulsive, and with extreme difficulty he said, "Do—you—suppose— Do—you—suppose——" and could say no more. But it was easy to supply the rest. "Do you suppose I should not know him, having been with him for thirty-nine years?"

In harmony with his religious sentiments he was a man of pure speech, of upright dealing, of modest demeanor, of benevolent heart, and of patriotic spirit. How could any one fail to recognize the advantage of daily association for many years with such a man?

I shall venture only one line as to a kind of dying testimony which we all value. In the few last weeks his mind was much clouded, and his speech nearly cut off, by the force of disease. Yet in a clear interval he was overheard to express his unreserved self-dedication to his Lord and Saviour.

The concluding remark may be offered that the Mint has sustained a great loss in losing so much skill, so much experience, so much exactness, such probity, and superiority to reproach, as were concentered in this one man. We cherish the remembrance of his name and services which impart dignity and character to the history of this Institution.

Immediately after the fact of his decease meetings were held at the Mint in Philadelphia and at the branch Mint in San Francisco, at which addresses were made by the present director of the Mint and two former directors, and other gentlemen, expressive of strong regard and esteem

both official and personal; and resolutions of the same tenor were unanimously adopted by the officers and workmen.

To this I will only add in conclusion, the unsought testimony, just received, of a gentleman who, after a service of fifty years in the Royal Mint at London, lately retired from the post of Queen's Assayer, which he had filled with great ability.

"I have to express my unfeigned regret at this loss to science, and especially our branch of it. I was not personally known to Mr. Eckfeldt; but I can say, his name and his works will live forever in the wide world. I sympathize in the loss his relations will have to sustain."

Stated Meeting, Oct. 18th, 1872.

Present, 17 members.

Dr. Emerson in the chair.

Dr. Agnew and Mr. Coleman Sellers, newly elected members, were introduced to the presiding officer, and took their seats.

Letters accepting membership were received from Mr. Coleman Sellers, dated Philadelphia, October 12th, and from Dr. R. J. Levis, dated Arch and Thirteenth Streets, Philadelphia, October 14th, 1872.

A letter of envoy was received from the Imperial Academy at Vienna, dated May 8th, 1872.

Letters acknowledging the receipt of publications were received from the Asiatic Society of Bengal, June 15th, 1872 (83 to 85, XIV. i.); the Imp. Academy, Vienna, November 7th, 1871 (83, 85, 86, XIV. i, ii.); the Zoological Society, London, 87 Hanover Square, September 30th, 1872 (83 to 88, XIV. i. and iii.); the Royal Soc. Edinburgh, March 18th, 1872 (82); the Lyceum of N. H., New York, October 7th, 1872, (88). the University of Virginia, October 7th, 1872 (88); the American Academy, Boston, October 8th, 1872 (88); the Maryland Historical Society, Baltimore, October 7th, 1872 (88); the University of the City of New York, October 10th, 1872 (88); the New Jersey Historical Society, Newark, October 8th, 1872 (88); the Maine Historical Society (88), announcing also the decease of Mr. Ballard; the Essex Institute, Salem, October 11th, 1872 (88); and the Georgia Historical Society, Savannah, October 9th, 1872 (88).

Donations to the library were received from the Academies at St. Petersburg, Vienna, Brussels and Boston; the Observatories of Dorpat and Montsouris; the Societies at Görlitz, St. Gall, Frankfort, Falmouth and Edinburgh; the Italian Geological Committee at Florence; the Geographical Antiquarian and Anthropological Societies, and M. Delesse, at Paris; the Meteorological, Geographical, Chemical, Geological and Zoological Societies, at London; the Revue Politique and Nature; the Peabody Museum, at Boston; Silliman's Journal; the American Chemist; the American Journal of Medical Sciences and Medical News; the American Journal of Pharmacy; Dr. Gross, of Philadelphia; Penn Monthly; and the Smithsonian Institution.

The death of Prof. John F. Frazer, a member of the Society, at the University, on Saturday, October 12th, in the 61st year of his age, was announced by Professor Kendall. On motion, Dr. LeConte was appointed to prepare an obituary notice of the deceased.

A paper for publication in the Transactions was presented, entitled, "On the Physical geography and geology of the island of Santo Domingo, with a map and four sheets of sections, by W. M. Gabb."

On motion, it was referred to a committee, consisting of Prof. Lesley, Dr. Leidy and Prof. P. E. Chase.

Communications were received from Prof. Cope, on a new Vertebrate Genus from the northern part of the Tertiary Basin of Green River, and descriptions of new Extinct Reptiles from the Upper Green River Eocene Basin, Wyoming.

Professor Chase explained his views of the values of his published comparative rainfall tables, and of the predictions permitted by his discussion of the same.

Pending nominations Nos. 697 to 705 were read. Nos. 697 to 702 were spoken to and balloted for.

Mr. Price read a letter from the Hon. W. S. Stokeley, Mayor of Philadelphia, in reference to the deposit of the Continental chair in the Hall of the State House.

The ballot boxes being scrutinized by the presiding officer,

the following named gentlemen were declared to be duly elected members of the Society:

Mr. Andrew Jackson Cassatt, of Philadelphia.
Mr. Clarence King, U. S. Geologist.
Mr. Horatio Hale, of Canada.
M. Paul Broca, M.D., of Paris.
Herr Franz Joseph Lauth, of Munich.
Dr. Isaac Norris, Jr., of Philadelphia.

And the meeting was adjourned.

ON A NEW VERTEBRATE GENUS FROM THE NORTHERN PART OF THE TERTIARY BASIN OF GREEN RIVER.

By Edward D. Cope, A.M.

(*Read before the American Philosophical Society, Oct.* 18, 1872.)

Anaptomorphus æmulus. Cope.

Dentition of the *ramus* mandibuli, In. 2, C. 1, P.M. 2, M. 3, total, 16; identical in number to those of *Simia* and *Homo*. It differs in many respects from these; there is no interruption in the series near the canine, and the symphysis though massive, is not co-ossified. Further details are, the last molar is three-lobed and elongated behind. The composition of the crowns of the preceding molars consists of four opposed lobes, which are very stout, and connected transversely by a thin ridge behind, or in close contact in front. The premolar tooth which is best preserved, is a perfect second, which, while having two roots, possesses a crown which stands almost entirely on the anterior, presenting a curved sectorial crest forwards and upwards.

Measurements.	M.
Length dental line	0.0148
" of last molar	.0030
" " ante-penult.	.0025
Width of "	.0020
Length of three molars preserved	.0070

DESCRIPTIONS OF NEW EXTINCT REPTILES FROM THE UPPER GREEN RIVER EOCENE BASIN, WYOMING.

By E. D. Cope.

Crocodilus (Ichthyosuchus) subulatus. Cope, sp. nov.

Some of the cervical vertebræ without hypapophyses. Their cups round. Dentition peculiar. One or two very long smooth compressed straight teeth in the front of the ramus mandibuli. These are followed abruptly by a closely set series of sub-equal teeth of not one-fourth the

size, varying little to the back of the jaw. The long teeth have subcompressed crowns with opposed cutting edges, and are smooth except at their bases. These are distantly sulcate, the separating ridges being acute. The smaller teeth are perfect cones and resemble those of Gars without their sulci.

There are more long teeth in the premaxillary bone than below. Pitting of cranium distinct, elegant. Length of skull about one foot. Length of long teeth 1.25 inches; of small ones .5 inch.

CROCODILUS SULCIFERUS. Cope, sp. nov.

A medium sized species with cranium deeply and roughly pitted. The chief character is at present visible in the teeth. The larger of these are of sub-cylindric and short conic crown, which is superficially grooved from basis to near apex; sulci coarse, open.

ANOSTIRA RADULINA. Sp. nov.

Based on two marginal bones one from the front, the other from the rear, of the carapace of an animal of twice the bulk of the largest *Anostira* yet found. Apart from size, the sculpture is peculiar. It consists in the anterior of closely packed vermicular ridges which run out flat on the posterior and upper edge. In the posterior, it consists of only closely placed minute tubercles over the whole surface.

	M.
Length front one on free edge	0.025
Width " " "	.028
Length posterior on free edge	.025
Width " " "	.025

RECENT MONTHLY RAINFALL IN THE UNITED STATES.*

BY PLINY EARLE CHASE.

(*Read before the American Philosophical Society, November 1st*, 1872.)

General Myer has kindly favored me with a transcript of the monthly reports of rainfall at the several Signal Service Stations, from October, 1871, to September, 1872, both inclusive. The reports were arranged, at my suggestion, in six groups, in order to exhibit the local influence of proximity to the great lakes, the gulf, or either ocean, and of situation on opposite sides of the Mississippi Valley. In the interpolations (which are all enclosed in brackets), for months in which the Bureau received no returns, I have usually given more weight to the general rainfall of the section than to the local precipitation. The deficient Philadelphia report, for October, 1871, was supplied from the records at Pennsylvania Hospital.

*Published by permission of Brigadier General Albert J. Myer, Chief Signal Officer, U. S. A.

Having thus completed the tabular data, I computed the normal percentages from the fourth successive means, in accordance with the general plan of my previous meteorological papers. The resemblance between the lake curve and the two interior curves is more striking, and the lake influence is less marked than I anticipated; the opposition between the Pacific and interior curves exhibits the effects of differences of temperature between polar and equatorial currents, in the air and ocean, at opposite seasons; the differences between the Atlantic, the Pacific, the Gulf, and the land curves, are quite as striking as any of the differences between the curves of lunar-monthly rainfall at different stations; and a *larger proportion of the solar than of the lunar influence is disguised*, by aggregating the accompanying six sets of solar normals, and the seven sets of lunar normals in the foregoing communication.

Monthly Rainfall of 1871—2 *at United States Signal Service Stations.*

GULF STATIONS.

STATIONS.	1871, Oct.	Nov.	Dec.	1872, Jan.	Feb.	Mar.	Apr.	May	June	July	Aug	Sep.
Indianola	(2.27)	(1.61)	(.73)	(1.25)	(1.72)	(2.10)	(1.49)	1.08	0.86	1.49	2.84	0.81
Galveston	17.81	5.67	2.40	4.61	2.27	2.77	5.96	2.21	3.39	0.34	2.63	2.33
New Orleans	9.09	7.14	1.46	5.10	4.77	9.18	5.01	3.14	5.34	6.43	3.75	2.10
Shreveport	(6.18)	3.04	1.30	5.25	5.89	4.11	7.18	9.10	2.70	1.62	0.40	2.91
Vicksburg	4.13	7.03	2.95	3.24	5.34	7.82	7.79	13.23	3.82	2.11	0.49	0.72
Mobile	5.23	0.68	1.36	3.69	8.09	12.76	4.35	3.78	6.33	13.57	1.69	2.11
Lake City	5.03	3.99	2.05	2.41	3.02	9.59	1.90	0.20	5.29	3.86	5.25	4.53
Punta Rassa	1.80	0.08	2.68	2.64	2.71	0.69	1.54	2.88	7.16	8.68	3.97	5.14
Key West	3.25	1.90	3.32	1.60	7.19	1.04	0.08	1.01	2.14	6.92	4.89	3.15
	54.89	38.04	17.35	29.79	40.91	50.06	35.30	36.63	37.03	45.02	25.91	23.80

LAKE STATIONS.

Milwaukee	3.37	2.54	1.55	0.90	0.34	0.53	1.84	2.92	3.67	1.98	1.89	8.72
Chicago	(2.29)	3.62	3.44	0.68	0.84	3.78	3.03	2.76	3.45	3.09	2.59	6.43
Cairo	3.81	2.93	4.25	1.44	2.26	2.02	4.52	5.00	1.79	3.45	0.19	2.56
Indianapolis	1.54	3.52	2.39	1.17	1.41	1.31	3.26	3.22	3.28	10.95	2.69	2.81
Cleveland	0.60	2.42	0.84	2.00	0.80	1.30	2.22	3.99	2.68	6.19	4.53	3.47
Toledo	0.78	1.48	1.91	1.20	1.10	1.68	1.87	3.97	3.96	5.76	1.16	3.38
Cincinnati	1.80	4.18	3.27	0.60	1.67	1.47	5.14	4.70	3.81	7.01	2.21	1.62
Marquette	2.97	0.65	0.33	0.39	0.31	0.37	0.88	6.60	3.32	4.79	2.74	8.30
Escanaba	2.94	1.94	1.41	0.90	1.19	1.24	1.50	7.21	2.45	7.11	2.87	3.97
Grand Haven	1.75	2.33	1.38	1.54	0.64	1.64	2.31	2.94	2.27	1.46	6.31	9.37
Detroit	0.69	2.76	1.88	1.05	0.69	1.22	2.15	5.64	2.85	2.63	2.60	3.84
Buffalo	1.64	3.60	2.55	1.94	2.21	1.30	1.43	2.23	3.52	1.66	1.94	4.34
Rochester	2.59	3.10	1.82	2.37	1.28	2.50	2.15	2.18	5.35	2.56	1.89	1.72
Oswego	1.44	2.96	1.30	1.48	1.17	2.43	1.44	2.72	4.48	1.84	0.71	2.44
Burlington	2.70	0.73	0.78	0.42	0.13	0.13	0.73	3.59	3.66	7.27	9.70	3.38
	30.96	38.76	29.10	18.08	16.04	22.92	34.47	59.67	50.54	67.75	44.02	66.35

PACIFIC STATIONS.

Portland, O.	(2 59)	2.77	7.62	6.56	12.13	5.28	2.96	0.92	1.52	0.20	.13	1.26
San Francisco	07	2.81	14.36	4.03	6.90	1.59	0.81	0.18	0.04	0.01	.00	0.04
San Diego	(.64)	1.19	1.39	0.99	1.63	0.46	0.26	0.12	.00	.00	.18	.00
	3.30	6.77	23.37	11.58	20.66	7.33	4.03	1.22	1.56	.21	.31	1.30

WESTERN INTERIOR.

STATIONS.	1871, Oct.	Nov.	Dec	1872, Jan	Feb.	Mar.	Apr.	May	June	July	Aug	Sep.
Fort Benton	(1 17)	(1.15)	1 30	0.27	0.34	0 82	0.67	0 64	1.14	4.62	0.61	1.82
Virginia City	(.98)	(.96)	1.43	1.45	0.79	0 29	0.35	1.78	0.74	2 73	0 00	0.28
Corinne	0.35	3.22	4.04	0.70	2.42	.55	1.43	2.66	0 47	0.11	1.04	0.14
Cheyenne	0.24	0.63	0.16	0.02	0 27	0.38	1.61	1.99	1.84	3 90	2.05	1.03
Denver City	(1.67)	(1.63)	(1.04	0.55	0.22	1.71	2.09	3.74	2.07	2.69	1.65	1.57
Santa Fe	.97	.95)	.61	0.34	0.20	0.13	5.14	0.45	2.44	2 62	2.98	0.27
Omaha	2.06	4.22	0.91	0.09	0.43	1.61	3.84	3.91	6.35	6.36	1.78	3.24
Fort Sully	1.76	1.72	(1.10	.35	(.49	(1.06)	(1.78)	2.98	2.34	6.48	1.53	0.21
Leavenworth	4.25	3.94	0.73	0.13	0.87	1.95	2.98	7.91	4.75	9.92	6.56	4.22
Duluth	4.19	1.47	2.05	0.86	0.46	0.85	1.80	4.62	4.46	5.83	2.84	5.01
Breckenridge	2.36	2.30	1.48	(.46	.66	(1.41)	(2.37	4.05	5.10	6.01	1.78	1.18
St. Paul	1.90	1.41	1.20	0.28	0.26	1.64	1.69	5.71	3.81	4.23	3.52	5.62
Davenport	3.19	3.33	1.61	0.13	0.10	1.82	5.06	4.46	3.78	3.80	8.91	5.30
Keokuk	5.22	2.89	1.46	0.07	0.39	2.88	3.66	3.70	5.81	6.77	1.97	2.26
St. Louis	2.07	1.83	1.17	0.64	1.15	2.43	3.17	5.97	4.28	4.41	0.98	3.45
	32.37	31.68	20.29	6.34	9.05	19.44	32.64	54.57	49.38	70.48	38.75	35.69

EASTERN INTERIOR.

Nashville	1.31	2.13	1.65	2.32	2.11	3.09	5 91	3.09	5.17	4.90	1.65	4.50
Knoxville	4.28	2.61	3.27	2.99	2.24	3.04	3.61	2.86	6.68	2.29	6.27	3.89
Louisville	1.85	2.51	3.29	2.18	2.26	1 41	8.40	4.49	6.19	3.67	2.45	4 41
Memphis	4.04	2.23	1.62	2.17	4.24	5.19	6.99	4.16	4.44	4.23	0.54	3.62
Pittsburgh	2 63	3.30	2.00	1.85	0.97	1.33	0.88	2.61	2.35	7.70	2.81	2 54
Philadelphia	4.86	4.09	1.57	0.95	1.12	3.67	2.60	3.15	4.29	9.20	7.81	3.66
	19.00	16.87	13.40	12.46	12.94	17.73	28.39	20.36	29.12	31.99	21.53	22.62

ATLANTIC STATIONS.

Portland, Me	6.55	6.37	3.00	0.77	0 35	1.44	1.60	3.23	5 95	2.87	6 97	3 12
Boston	5.88	6.42	3 38	2.11	2.31	4 05	1.31	3.29	4.84	4.00	10.68	6.04
New London	8 35	5.50	2.78	2 46	0.96	2.93	2.30	3.16	2.78	5.35	6 06	6.98
New York	7.07	3.76	1.19	2.34	1 44	3.93	2 49	2.25	2 93	9.36	6.08	3.44
Baltimore	3 11	3 24	1.90	0.88	1.46	3.06	3 06	1.44	4 16	1 58	4 59	5.06
Cape May	4.91	6.42	2.90	2.99	2.99	6.61	0.92	1 50	2.15	3.27	3.09	4.51
Washington	1.50	4.85	1.36	0.23	0.93	3.22	1.74	1.43	2.78	0.82	5 72	3 92
Lynchburg	1.60	3.76	1.12	2 08	1.99	4.24	3.20	3.15	2.53	1.56	2 27	1.26
Norfolk	4.14	5.76	2.18	2.91	7.33	4.51	3.53	5.68	5.05	3.63	3.20	2.40
Wilmington	3 02	4 46	3.90	3 62	5.20	6 42	0.97	4.89	2.87	5.54	11 15	8 22
Charleston	4.76	4.09	3.67	3.78	5 13	9.78	2.46	6.30	1.87	2 30	7.81	7 88
Savannah	3.55	2.22	1.59	2.09	4.65	10.18	2.75	5.22	9.52	4.36	12.31	3.52
Augusta	1.62	7.78	5.98	4.20	5.87	10.88	2.95	5.33	4.77	6.87	4.10	1.33
Jacksonville	3.62	3.63	2.65	3.44	2.70	7.32	2.39	1.25	6.97	2.92	6.41	10.65
	59.68	68.26	37.60	33.90	43.31	78.57	31.67	48.15	59.18	54.53	90.44	68.33

Normal Percentages of Rainfall.

	Atlantic Stations.	Gulf Stations.	Pacific Stations.	Lake Stations.	Western Interior.	Eastern Interior.	Mean Solar.	Mean Lunar.*
January	75	86	239	55	39	65	93	99
February	87	107	209	51	39	73	94	97
March	95	116	143	66	64	93	96	98
April	89	110	73	95	103	111	97	101
May	87	104	34	124	140	122	102	100
June	99	105	18	140	162	132	109	104
July	116	100	10	143	162	133	111	103
August	128	90	12	138	138	120	104	106
September	126	95	27	126	112	106	98	104
October	115	107	70	107	98	93	98	95
November	100	98	147	87	83	81	99	95
December	82	81	218	70	59	70	97	98

* The twelve normal ordinates of the Mean Lunar curve are obtained from "Aggregate B," in the "Normals of Lunar-Monthly Rainfall." The aggregates for two and a half days are added together, to obtain the normal aggregate for one-twelfth of a month, and the normal percentages computed from the results. E. g.; the 1st day, added to three-fourths of the sum of the 30th and 2d days, gives the normal aggregate for the 1st twelfth; the 3d and 4th days, added to one-fourth of the sum of the 2d and 5th days, gives the normal aggregate for the 2d twelfth.

LUNAR-CYCLICAL RAINFALL IN THE NORTHERN TEMPERATE ZONE.

By Pliny Earle Chase.

(*Read before the American Philosophical Society, Nov.* 1, 1872.)

My discussions of lunar-monthly rainfall, (*ante*, x., 439, 533; xi., 203; xii., 179, 523,) embracing observations in Europe, Asia and America, near eastern and western shores of oceans, in regions of monsoons and return trade-winds, near equatorial and polar currents, seem to be sufficiently varied in their character to justify a first approximation to the normal curve for the Northern Temperate Zone. The stations are so well distributed that the influence of local "establishments" must be, to a great extent, eliminated, and it seems reasonable to presume that the residuals represent, with some degree of accuracy, the precipitation which is occasioned by the lunar modifications of the average atmospheric currents. I have given equal weight to the normals for each station, but as the Toronto observations cover only nine years, and those at Chiswick are of the same general character as those at Surrey, I give two complete aggregates: A., embracing stations 2 to 6 inclusive, and B., 2 to 8 inclusive; and one partial aggregate, C., for all the stations.

NORMALS OF LUNAR-MONTHLY RAINFALL.

Lunar Day.	Museoorie, 13 years.	Philadelphia, 40 years.	Surrey, 40 years.	Providence, 30 years.	San Francisco, 23 years.	Lisbon, 16 years.	Aggregate A.	Chiswick, 40 years.	Toronto, 9 years.	Aggregate B.	Aggregate C.
1	86	93	100	104	97	104	498	104	93	695	781
2		93	98	100	97	103	491	105	104	700	
3		96	97	98	94	98	483	105	103	691	
4		100	100	98	92	91	481	105	94	680	
5		101	102	100	96	86	485	103	92	680	
6		99	102	103	104	81	489	100	100	689	
7		97	100	107	107	81	492	96	113	701	
8	115	97	101	107	108	85	498	97	117	712	827
9		97	105	101	107	91	501	102	110	713	
10		98	107	93	103	94	495	106	98	699	
11		98	104	87	97	110	496	106	91	692	
12		97	101	85	99	123	505	103	95	703	
13		95	98	87	110	128	518	101	105	724	
14		92	97	90	125	123	527	98	110	735	
15		89	98	90	138	116	531	98	104	733	
16	86	91	98	89	134	114	526	98	91	715	801
17		90	97	93	115	118	522	96	85	703	
18		100	96	90	105	127	536	93	90	719	
19		116	97	104	104	131	552	95	102	749	
20		117	99	108	96	123	543	102	110	755	
21		112	103	111	85	104	515	109	110	734	
22		107	104	110	83	82	486	108	104	698	
23	113	105	101	106	86	69	467	101	103	671	784
24		105	98	102	88	70	463	95	106	664	
25		102	99	99	89	77	466	93	108	667	
26		98	101	99	86	84	468	94	106	668	
27		100	100	103	81	89	473	94	101	668	
28		103	99	109	85	95	491	95	91	677	
29		100	100	111	93	99	503	98	81	682	
30		96	101	108	96	102	502	101	82	685	

Each of the complete aggregates indicates an excess of rainfall during

the half-month of lunar opposition; a pretty regular increase of rain from the first octant, when the moon is on the meridian at the time of greatest solar heat, until nearly the fifth octant, when her direct meridional influence is exerted at the time of morning low barometer; average rain when that influence is felt at sunset, or at the morning barometric maximum; a principal maximum, near the morning barometric minimum, and a principal minimum near sunrise, when the nocturnal precipitation is over; other minima soon after sunset, after the maximum heat of the day, and after midnight. These features all seem so natural and so simply explicable, that I am unable to regard them as other than typical.

I regret that Mr. Hennessey's observations at Mussoorie were communicated only for the days of quarterly change. They appear to indicate a curve still more strikingly similar to that of the solar-hourly rainfall, and the indication is corroborated by their influence on the general aggregates, as shown in Aggregate C.

It would be possible, even with the data now at my command, to form interesting approximations to the normal lunar curves for each calendar month, but I prefer to wait for observations from a much larger number of stations, before undertaking any more minute calculations than I have embodied in the accompanying table. Even these normals may be employed in connection with barometric and thermometric normals in the study of weather changes; provided such allowances are made as are obviously required, for the blending of currents over or near the great Lakes, the Gulf, and the ocean. Such limited use of them as I have already made, has strengthened my conviction that the day is not far distant when the normal lunar influence will be ranked among the important elements for calculating the disturbances, and the tendencies towards equilibrium, which determine all meteorological fluctuations, and render satisfactory forecasts practicable.

Stated Meeting, November 1, 1872.

Present, 16 members.

Vice-President, Mr. FRALEY, in the Chair.

The Rev. Mr. Nichols, a newly elected member, was presented to the presiding officer and took his seat.

A circular letter in reference to a new table of logarithms was received from Mr. Ed. Sang, dated No. 2 George street, Edinborough, Oct. 15th, 1872.

A letter was received from Dr. William Elder, addressed to the Curators, dated No. 1824 Mount Vernon Street, Philadelphia, Oct. 31st, 1872. On motion the Curators were

desired to acknowledge the donation of the Bushrod Washington Chair, described in the letter, and to return the thanks of the Society for the same.

Letters of acknowledgment were received from the Rhode Island Historical Society, (Proc. 88) and Yale College Corporation (Proc. 88).

Donations for the Library were received from the Revue Politique, and London Nature, the Geological Survey of New Hampshire, Silliman's Journal, and the Franklin Institute.

The Committee to which was referred Mr. Lyman's map and description of the Staley's Creek Iron Ore District, reported in favor of its publication in the Transactions. The report was accepted and the publication ordered.

The Committee to which was referred Mr. Gabb's Memoir on the Geology, &c., of Santo Domingo, reported in favor of its publication in the Transactions. On motion the report was accepted and the publication ordered.

The death of Mr. Constant Guillou, at Philadelphia, the 20th ult., was announced by the Secretary.

Mr. James desired to place on the minutes that he had duly returned the MSS. letter of Dr. Franklin and the map accompanying Pursh's MSS., Botanical Journal, which he had been permitted to borrow from the library.

Dr. Emerson exhibited one of the bricks of a chimney scattered by lightning in the storm of the 25th ultimo; a chimney belonging to a house in which he was sleeping at the time.

Mr. Lesley desired to place on record authentic data respecting fourteen oil wells sunk by the Brady's Bend Iron Company, at and near their works, on the Allegheny River; and explained the importance of facts, so obtained, when comparable, in view of the general inaccessibility of the Sub-carboniferous formations underlying the Oil Regions. A discussion of oil theories and of the history of the oil discoveries followed, in which Mr. Lyman, Mr. Gabb, Dr. Le Conte, and other members took part.

Mr. Chase offered for publication in the Proceedings a first approximation to a curve of Normal Temperature in the Northern regions of the Continent.

Mr. A. H. Smith described his observations of the Sub-alpine botany of the North Shore of Lake Superior, in the Summer of 1871, and of its absence in the Lake Nibbegong region, further north, which he had explored in the Summer of 1872; this change of flora he was led to ascribe to the fact that the waters of Lake Superior were much colder than those of Lake Nibbegong. His collection of mosses he had placed in the hands of Mr. James for examination. He described the ascent of the Nibbegong River and the thousand islands in the lake itself, which has scarcely been visited by any observers who could report scientific facts.

Mr. Gabb instanced an analogous change of flora from the coast to the interior of the northern part of Lower California.

Dr. Le Conte said that he would assign a hygro-metric cause for this difference, and added that a similar difference was known to exist between the faunæ of the coast and the interior as far across as to the banks of the lower Rio Grande; and that the line of distinction was sharp and sudden, being drawn along the summit of the coast range of mountains, a barrier not more than 3000 feet high at the place to which he referred. It was evident that the wet winds of the west flank of this barrier and the dry air of its eastern, which made the change in flora and fauna.

Professor Haldeman introduced the topic of the Rhyme-law of the Sonnet in European literature. He had made extensive collections of Sonnets and studied their construction for the purpose of discovering a normal rhyme arrangement. So far from that, he had already tabulated 600 (six hundred) arrangements of the sonnet with a prospect of adding to his tables more.

Pending nominations, Nos. 703 to 707 were read.

And the meeting was adjourned.

A Record of Fourteen Oil Wells at Brady's Bend, Armstrong County, Pennsylvania.

By. J. P. Lesley.

(*Read before the American Philosophical Society, Phila., Nov, 1st*, 1872.)

Having recently requested Mr. Persifor Frazer, Assistant Professor of Chemistry in the University of Pennsylvania, to examine for new estimates of quantity the coal areas which have escaped erosion, in the country on the two sides of and closely adjoining the Allegheny River, at the remarkable ox-bow bend in its course, 70 miles above Pittsburgh and 60 miles below Oil City; he brought back with him a MSS. report of of the wells bored by the company on the river banks and along the beds of the ravines descending to it from the west. We owe this report to the kindness of Stephen Halbrook, Esq., Superintendent of the Brady's Bend Iron Works.

It is needless to recapitulate the history of the oil discoveries, and the gradual extension of the oil producing districts from Titusville and the line of Oil Creek eastward to the Tidioute district, southeastward to the Clarion, westward to French Creek, and southward via Oil City, Franklin, Parker's Landing, and Brady's Bend, to the neighborhood of Butler, where the last discovery excitement is now raging. It is only necessary to refer to my report on the geological grounds for believing the middle Allegheny River districts to be productive oil country, published in the Proceedings of this Society, in 1865.* In that paper I have sufficiently described the *locale* of the wells now to be described. These records may also be compared with similar records communicated to the Society and published in its Proceedings of April, 1865.

The "Engineers' Datum" of the following table is an assumed level, *one hundred feet lower* than a mark made on the Brady's Bend Iron Company's warehouse, on the river bank, showing the extreme height reached by the great and disastrous freshet of March 17, 1865.

No.	Height of well mouth above Eng. datum.	Depth of well.	Depth below river, highest water mark.	First yield in barrels per day.	Present yield per day.
1.	96 feet.	?	?	?	1 bbl.
2.	.232	1,400	1,268		*no sand rock.*
3.	97.62	1,111	1,113	5+ bbls.	1 bbl.
4.	97.69	1,262	1,264		*abandoned.*
5.	.100.31	1,105	1,105	7 bbls.	2 bbls.
6.	.300.48	1,290	1,090	5½ bbls.	4 bbls.
7.	.437-41	1,414	1,077	9 bbls.	8 bbls.
8.	.379.18	1,345	1,066	840 bbls.	150 to 200 bbls.
9.	.101.38	1,065	1,066	4½ bbls.	3+ bbls.
10.	.330.27	1,300	1,070	1 bbl.	*abandoned.*
11.	.111.13	1,200	1,189		*powerful gas blow.*
12.	.216.50	1,213	1,095½	12 bbls.	13 bbls.
13.	.426.38	1,402	1,076	3 bbls.	2 bbls.
14.	.359.89	?			*to be sunk to 4th sand.*

* See Proc. A. P. S., vol. 10, p. 61.

From the above table, it appears that all the oil-producing wells mentioned in it get their supply from one stratum lying in an undisturbed and horizontal position, varying in their actual depths below a fixed datum level from 1,113 to 1,066 feet, a difference of only 40 feet. This difference is due to three causes, viz. :—1. The different depths in the oil-bearing stratum penetrated by the bottom boring of the wells; 2. The slight inequalities in the upper surface of the stratum; 3. And chiefly, to a general slight dip of the rocks, both from the northwest and from the southeast, in towards the centre line or axis of the trough or basin which here crosses the Allegheny River in its northeast-southwest course; and also to a still slighter and almost insensible decline of the axis of the basin itself southwestward.

The table also confirms what was proven years ago, long before the fact was acknowledged by oil men, namely, that it makes no difference whether a well is started in the valley bottom or on the hill tops, provided it goes down to the uniform and nearly horizontal oil-bearing sandrock. For some of these wells have their mouths at elevations more than 300 feet greater than others. Some on the river bank, and others high up at the heads of side ravines. The great No. 8 well was commenced at an elevation (379—96—) 283 feet higher than those on the river bank which yield only from one to three barrels a day.

The following table shows the thickness of the third sandrock where it was passed entirely through :

No. 2.—No sandrock found and no oil.

No. 4.—Sandrock, 26 feet; hard fine white sand.

No. 5.—Sandrock, 27 feet; fine pebbles.

No. 6.—Sandrock, 16 feet; with slate partings.

No. 7.—Sandrock, 27 feet; pebbles pretty coarse.

No. 8.—Sandrock, very coarse and open.

No. 9.—Sandrock, pebble very fine and close, very little gas.

No. 10.—Sandrock, 10 feet; pebbles pretty fine, except in one thin streak.

No. 11.—To sandrock, no oil, but great gas blow, doubtless from a fissure.

No. 12.—Sandrock, 17 feet, all pebbles; steady flow of oil.

No. 13.—Sandrock, 13 feet; coarse open pebbles; and a fair amount of gas.

No. 14.—Sandrock, 13 feet; large coarse pebbles; fair amount of gas. Other noteworthy facts are as follows :

No. 1 well, on the river bank, one half mile above the rolling mill, begun March, 1865, finished 1866.

No. 2 well, at the mouth of Cove Run, May, 1866—June, 1870.

No. 3 well, on the river above the mill, commenced August, 1868—pumping in September, 1872, 1 barrel a day.

No. 4 well, on the river above the mill, May, 1869—March, 1870. Cost $10,405. Record of strata given below.

No. 5 well, on the river above the mill, June, 1869—April, 1870. At 931 feet struck so powerful a gas vein, that the bore-hole was deluged with water and abandoned for four months. In June, 1871, a three quart nitro-glycerine torpedo was exploded without increasing the production of oil. The pebble rock was almost as fine as sea-sand.

No. 6 well, on Queenstown Run; August, 1870—April 5, 1871; drilled with the water cased out; all the previous wells were drilled in water; casing commenced at 357 feet; not much gas.

No. 7 well, on Queenstown Run; August 7, 1870—March 1, 1871; water cased out at 512 feet; some gas at 1,050; commenced pumping about 9 barrels a day, and has produced up to September 7, 1872, 4,133 barrels.

No. 8 well, on Queenstown Run; June 26, 1871—September 22, 1871; water cased out; first show of oil September 22, and began to fill up very slowly. At 12.35 A. M., September 23, struck a vein of gas and oil which spouted over the top of the derrick, and was fired by the night lamp hung in the derrick, burning the rigging down. The spouts occured every two minutes. At 9 A. m. the fire was extinguished and the oil began to fill the tank at the rate of 35 barrels an hour, but gradually calmed down to about 60 barrels a day during the first month, and October 22 ceased to flow. Tubeing and sucker rods were then put in, and she began to flow again at the rate of 150 barrels a day.

This well has been cleaned out many times to keep her in good running order. Immediately after any one such cleaning she produces from 70 to 90 barrels a day, and gradually falls off to about 20 to 25, when it is understood that she again needs cleaning. In fifty weeks she has produced 9,505 barrels. There is not much gas except when flowing.

No. 9 well, on the river opposite Catfish; June 24, 1871—October 24, 1871; water cased out; cost $5,750.

No. 10 well, on Lower Campbell Tract; July 10, 1871—May 22, 1872; water cased out. After passing through third sand at 1,300 feet, put in a 4 quart torpedo, which seemed to have very little effect. Sand pumped for two days afterwards and found that she filled up with less than a barrel of oil per day, and therefore concluded it was useless to tube her. Not much gas at any time.

No. 11 well, on river half mile below the mill; August 24, 1871—June 24, 1872; water cased out at 437 feet, Struck very heavy vein of gas at 858 feet.

The gas from this well, by calculation, would supply fuel to run the rolling mill and machine shop boilers, being therefore equal to 100 tons of coal per week.

The pressure of gas would sometimes lift the tools 20 or 30 feet in the hole, tools weighing 1,700 pounds and rope 300 pounds. The flow of gas is enormous and continuous.

No. 12 well, on Queenstown Run; December 9, 1871—April 12, 1872; water cased out at 394 feet. Struck heavy vein of gas February 2, at

725 feet, which caused a flow of water until March 1, when casing was put in and the water stopped off.

Struck oil at the top of third sand April 4, at 1,183 feet, the rock being nearly all good pebble rock; after passing through it (1,200 feet) drilled 12 feet into slate for a pocket; tubed well April 12; commenced pumping 12 barrels a day, and the well is now doing 13 barrels. Much gas all the time. Cost $6,557.

No. 13 well, on Queenstown Run; January 2, 1872—May 8, 1872; water cased out at 290 feet. Best show of oil at 1,390. Cost $6,671.

No. 14 well, on Queenstown Run; June 11, 1872—September 2, 1872; water cased out at 227 feet. Little oil in third sand; will push it deeper.

It only remains to give vertical sections of the Measures passed through, premising, that the Great Conglomerate No. XII, the base rock of the Coal Measures forms the low cliffs at water level in the river valley; all the hills being built up of the nearly horizontal Lower Coal Measures or Allegheny River System, and the underground of Sub-Carboniferous and Devonian.

The following records of wells No. 4 and No. 5 of the foregoing description were made from labels on sample bottles, marked daily by the well drillers, and are not supposed to be perfectly reliable, but are nevertheless for the most part accurate notations of the character of the Sub-carboniferous and Upper Devonian Measures penetrated in reaching the oil-bearing strata.

RECORD OF OIL WELL NO. 4.

Struck the "mountain sandrock" at a depth of 50 feet.

Got through it at	240 feet.
Grey sand at	898 "
Grey sand at	933 "
Grey sand at	940 "
Dark gray sand	944 "
Black slate	947 "
Dark rock	952 "
Dark rock	955 "
Gray sand	965 "
Slate rock	976 "
Black rock	992 "
Black sand	998 "
Grey sand	1,008 "
Grey sand	1,003 "
Blue sand, hard	1,005 "
Black sand, hard	1,008 "
Blue sand, pretty hard	1,012 "
Slate rock	1,015 "
Hard sand	1,038 "
Sand	1,085 "

Sandrock	1,100 feet.
Red sandstone	1,126 "
Black sand	1,140 "
Grey sand	1,141 "
Grey sand	1,143 "
Mud	1,144 "
Blue slate	1,145 "
Soft slate	1,146 "
Soft slate	1,147 "
Shelly	1,148 "
Slate	1,150 "
Slate rock	1,152 "
"	1,162 "
"	1,165 "
Shelly rock	1,172 "
Slate rock	1,176 "
"	1,181 "
"	1,183 "
"	1,191 "
Blue slate	1,194 "
"	1,197 "
Shelly rock	1,211 "
Traces of oil	1,220 "
Slate	1,235 "
Slate rock	1,248 "
Dark slate	1,252 "
Slate—well abandoned at	1,260 "

RECORD OF WELL NO. 5.

Struck the mountain sandrock at	45 feet.
Got through it at	215 "
Grey sand	350 "
Slate rock	400 "
"	440 "
Soft slate rock	460 "
Grey rock	490 "
Slate rock	510 "
Slate shells	530 "
Slate rock	560 "
"	580 "
"	620 "
Shell rock	640 "
Slate rock	660 "
"	670 "
"	690 "
"	710 "

Sandrock	715 feet.
"	720 "
"	730 "
Slate rock	745 "
Red rock	750 "
Pebble rock	775 "
Sandrock	779 "
"	780 "
"	790 "
Slate rock	795 "
Sandrock	805 "
Red rock—	
Grey sand	808 "
Sandrock	812 "
"	815 "
"	820 "
"	822 "
"	824 "
"	826 "
Red rock—	
White sand	825 "
Rock	830 "
"	840 "
Grey sand	844 "
"	847 "
"	848 "
Sandrock	850 "
Blue rock	855 "
Sandrock	860 "
Black sand	865 "
Sandrock	896 "
"	930 "
Red rock—	
Sandrock	939 "
"	940 "
"	941 "
"	943 "
Shelly rock	948 "
"	951 "
"	954 "
Slate Rock	965 "
Red rock	972 "
Hard sand	986 "
Soft sand	998 "
Dark rock	1,018 "
Red sandrock	1,026 "

Slate..... 1,050 feet.
Shelly rock..... 1,055 "
THIRD SAND rock..... 1,073 "
Sandrock..... 1,076 "
" ..... 1,078 "
Slate and shelly..... 1,084 "
Pebble rock..... 1,085 "
" ..... 1,090 "
Sandrock..... 1,092 "
" Tubed well..... 1,100 "
and began pumping about 7 barrels in 24 hours.

It is a pity that the above records are so defective. The intervals between the numbers given are in many cases large and not noted, and must not be taken as the *thicknesses* of the rocks named.

There is, however, a positive value in all such records, however defective, as may be noted by the recurrence of the *red rocks* in the above lists. These may define the position of the great red formation of the Palæozoic series No. IX of the Pennsylvania State Survey, the representative of the Old Red Sandstone of English geologists, and the Catskill Formation of the New York geologists.

In Well No. 4 it is noted once only as being struck at 1,126 feet.

In Well No. 5 it appears at 750, 805, 826, 930, 972 and 1,026 feet.

The thickness of the Conglomerate No. XII is accurately determined in Well 4 at 190 feet, and in Well 5 at 170 feet.

The thickness of the Conglomerate No. XII in the salt well 45 miles further down the river, as determined (not with entire accuracy) from the Record, published on p. 65, vol. X., of the Proceedings A. P. S., April 1865, is $494\frac{1}{2} - 334\frac{1}{2} = 160$ feet; or, if the top of XII be placed at the "White Sand" $440\frac{1}{2}$ and all the "Gray Sandrocks" be included down to 666′11, = 220 feet.

At Sligo Furnace on the Clarion (p. 63, vol. X.), the Conglomerate No. XII, seems to be only 117 feet thick, soft red slate of XI under it only 3 feet thick, and the red and blue slates of IX lie 786—183 = 603 feet below its base, or 720 feet below its top.

The resemblance of this to the record of Well No. 5, given above, is very observable. Thus, in Well No. 5, the red rocks of IX are first struck at 750—45 = 715 feet beneath the top of the Conglomerate.

In the Sligo Well (15 or 20 miles to the northeast of it), the top of the red rocks is 786—66 = 720 feet beneath the top of the Conglomerate.

In the Well No. 5, the redrocks are noticed at intervals from 750 to 1026 = 276 feet.

In the Sligo Well, the red rocks occupy an interval of only 118 feet.

It must be taken into consideration, however, that the lowest red rocks of the well No. 5 may represent not No. IX, but the Red Beds of VIII, described in my report to Professor H. D. Rodgers, in 1841, and published in his Final Report of the Geology of Pennsylvania, under the

head of the Geology of the Wellsborough Valley or Tioga River District in Tioga County. To trace the thinning away of these calciferous and ferriferous red beds of VIII (Lower Divonian) on their way towards Ohio, underground, is one of the desiderata of American geology.

Other well-boring records are published on pages 227 ff, vol. X, Proc. A. P. S., but most of them are confined to the Coal Measures. Those on p. 238 ff, however, penetrate the Devonians to considerable depths and show the red rocks in positions analogous to those described above.

In one well, at the head-waters of the Clarion, the mouth of the well being 370 feet below a coal bed, and also below the bottom of XII, the red rocks of IX (?) occur from 216 to 415 — an interval of 200 feet, which is about the normal thickness of IX in this zone of its decresence westward. The Manchester (Tioga river) red beds (?) were struck at intervals from 925 to 956 — 41 feet, *i. e.*, with an interval of 510 between their top and the bottom of IX.

In the Glade Well near Pithole (page 241, vol. X), in the Oil Creek country, the red slates were first struck at 196 and got through at 318, the interval being 122 feet. Some red shale was then struck near the well bottom (abandoned, no oil) at 612, *i. e.*, 294 feet below the bottom of the upper red shales.

These also probably represent IX and the Manchester red beds, with a diminished interval due to westing.

These red rocks correspond to the Marshall group of Michigan, of Winchell (Proc. A. P. S., vol. XI., p. 74), the Gritstone redrocks above and the Chocolate shales below (the latter just over the Hamilton) in Ohio (Idem, p. 75), and to the Brown shales of the Keokuk group of Indiana. They are very noticeable to the traveller on the railways crossing Northern Ohio.

NOTE.—I have received the following letter of explanation respecting the wells at Brady's Bend:

ST. LOUIS, MO., *November* 13, 1872.

Dear Sir:—The detailed surveys were begun and mostly made under my direction, and the wells Nos. 6, 7, 8 and 9 were located by me. This would be of no interest to you or the public were it not that the location of these wells was the result of a long, carefully pursued, and at least apparently successful investigation into the laws of the distribution of the oil in the "sandrocks."

You had already shown that these rocks existed there and at what depth, and had also shown that the general stratography of the district rendered it reasonably certain that oil would be found there, and this had been confirmed by the results of boring in the case of two of the five wells sunk.

I tried to find the law of distribution in its application to narrower limits, so as to decrease to the utmost the risks, and increase to the utmost the chances in sinking wells.

Of the five sunk before I went there, two were productive; of the four sunk since I left, one is productive; of the four I located, namely, Nos.

6, 7, 8 and 9, all are productive. No. 9, which is the least productive of the four, was located under restriction to the Lower Campbell tract. No. 8, the most productive, was the last one I located without restriction. Nos. 6 and 7 were both down before any other well was started in the Whiskey Run or Queenstown Run field. The same principles which guided the locating these wells, led me to advise the Brady's Bend Iron Company against trying the Upper Campbell tract, and the results of boring there by other parties have confirmed their correctness, and there have been so many confirmations that my confidence in the principles amounts to conviction.

In opening the Whiskey Run or Queenstown Run field, I simply followed the general line of strike from the Armstrong Run field; but in locating individual wells I sought lines and areas of deposition of coarse pebbles in the "sandrocks" out of broken condition of the "sandrocks."

I had not so far completed the research into the laws which govern the direction and position of these lines and areas that I felt free to communicate them when I left the oil country, but hope to push the investigations further hereafter. Meanwhile it may be of some interest that the above results have followed an effort pursued by scientific methods to find and apply such laws.

Yours, very respectfully,

JAMES E. MILLS,
Vice President Big Muddy Iron Company.

Stated Meeting, November 15th, 1872.

Present, nine members.

Vice-President, Mr. FRALEY, in the Chair.

A photograph of Mr. H. M. Phillips was received for insertion in the Album.

Letters accepting membership were received from Mr. Isaac Norris, Jr., dated Philadelphia, October 31st, 1872, and from Mr. A. J. Cassatt, dated 2030 Delancey Place, Philadelphia, November 6th, 1872.

Letters of acknowledgment were received from the Smithsonian Institution (Proc., No. 78), and the Nat. Verein at Bremen (87), September 7th, 1872.

Donations for the Library were reported from the St. Petersburg Observatory; Antiquarian Society at Copenhagen; R. Academy at Berlin; German Anthropological Society; Museum of Natural History at Paris; Paris Anthropological Society; Annales des Mines; Revue Politique; Nature; L. & H. S. Quebec; Boston S. N. H.; Yale College;

American Chemist; Penn Monthly; Am. J. of Pharmacy; Medical News; Academy of N. S. Philadelphia; and Dr. Jarvis, of Dorchester, Mass.

The death of Gen. George Gordon Meade, on the 6th instant, at Philadelphia, aged 56, was announced by Mr. Trego. On motion, Gen. A. A. Humphreys was appointed to prepare an obituary notice of the deceased.

Mr. Gabb described the results he arrived at in making up a summary from tables of undoubted Miocene fossils, collected by him during three years of exploration in Santo Domingo. These tables double the fauna hitherto described. Instead of the normal percentage of extinct to recent species according to Lyell's formulas, it appears that the San Domingo Miocene holds 217 extinct and 97 living forms; these living forms existing on both sides of the present barrier of Central America, on top of which barrier lie Miocene rocks. Mr. Gabb stated that he had just finished the study of the Miocene Fossil Mollusca, collected during his recent geological examinations in Santo Domingo. He found 217 extinct species, and 97 which he recognized as living; 15 of these latter are peculiar to the "Panama Province," having disappeared from the Caribbean waters since the Miocene period. One or two are found in the Eastern seas only, and others are now living on the opposite side of the Atlantic, or on the Atlantic coasts of North and South America; while still others are closely allied to species or belong to genera only living at present in the seas of Australia and Southern Asia.

The most interesting feature connected with these fossils, however, is that notwithstanding the proportion of living to extinct forms is about one-third, yet, from the "facies" of the collection, from the presence of antique types among the genera, and from the vertebrate remains, such as *Carcharodon*, *Megalodon* and other well-known Miocene species, there seems little doubt but that the formation was correctly referred to that age by previous writers, such as J. Carrick Moore, Etheridge, and Duncan.

Lyell established the rule many years ago, that the typi-

cal Miocene contains but 17 per cent. and the Pliocene from 35 to 50 per cent. of living species. But that rule, while it applies perfectly well to the local deposits on which it was based, is too empirical to be followed elsewhere, except in a very general manner and where the other data are in accord.

An essential objection to the numerical rule exists in the different values that students place on specific characters. No two writers agree on this subject. Besides, as regions become more thoroughly worked up, discoveries of additional fossils, or the finding of living species, previously known only as fossils, vary the proportions constantly. The general deductions, therefore, drawn by an experienced palæontologist from large collections, are safer guides than any table of percentages.

MUS. COMP. ZOOLOGY,
Cambridge, Mass., Dec. 3, 1872.

MY DEAR PROF. LESLEY:

The steamer did not sail on Saturday and I have availed myself of the delay to run up here. It was very fortunate, since I have had the opportunity of seeing Dr. G. A. Maack, and of learning from him some of his geological results on the late Selfridge Expedition on the Isthmus. Please have the following note added to my paper, with the permission of the Society:

The results of the explorations of Dr. Maack last year, on the Isthmus of Darien, put at rest the question of the late geological origin of the Isthmus. He found three late Tertiary strips extending entirely across, proving three channels at least in the Miocene, and some of the deposits indicate a much later era of elevation. One of these, 10 miles inland from Panama, evidently Post Pliocene, is at least 150 feet above the tide.

In a very cursory examination of his fossils I detected the following species, also found in Santo Domingo:

Melongena melongena.
Murex recurvirostris.
Malea ringens.
Terebra robusta.
Conus pyriformis.
Natica sulcata.
Cerithium plebium.
Turritella.
Cypræa exanthemata (v. cervinella).
Venus paphia.
Cardium Haytense.
Pecten papyraceus.

Dr. Maack in his report calls the older beds of Panama, Pliocene. They

seem to me nearer in age to the rocks which, in Santo Domingo, I called Miocene, but whatever be their real age, the one fact is well established: The Isthmus was elevated at a period not remote from the age of the great volcanic outflow of the Sierra Nevada.

Yours, sincerely,

W. M. GABB.

The minutes of the Board of Officers and Council were read.

Pending nominations, 703 to 707, and new nominations, 708, 709, 710, were read.

And the Society was adjourned.

Stated Meeting, December 6th, 1872.

Present, 13 members.

Vice-President, Mr. FRALEY, in the Chair.

Letters accepting membership were received from Mr. Broca, dated Paris, November 14th, and Mr. Hale, dated Clinton, Ontario County, Canada, November 26th, 1872.

Photographs of Mr. B. S. Lyman and Mr. W. M. Gabb were received for the Album.

A letter desiring the establishment of correspondence, was received from Mr. W. A. Smith, Secretary of the Tennessee Philosophical Society, dated Columbia, Tennessee, November 21st. On motion, the Society named was ordered to be placed on the list of correspondents to receive the Proceedings.

A letter from M. de Koninck, dated Liège, September 3d, requesting the Society to supply deficiencies in his suite of its Proceedings, was read, and, on motion, the request granted.

Letters of acknowledgment were received from the Carolinian University, at Lund, August 1st (XIV., i. ii., 73 to 85); the Physical Society, at Berlin, September 1st (XIV., i. ii., 83 to 86); the Society at Bonn, August 6th (84 to 86); the

Batavian Society, at Rotterdam, August 29th (XIV., iii., 87); the Holland Society, at Harlem (86), requesting a supply of deficient parts; the R. Library, at the Hague, July 24th (XIV., iii., 87); and the Rhode Island Historical Society, Providence, November 19th (88).

On motion, the request of the Holland Society, at Harlem, was referred to the Publication Committee, with power to act.

Letters of envoy were received from the University of Lund, August 1st; the Physical Society of Berlin, September 1st; the Royal Academy, at Amsterdam, September 15th; the Batavian Society, at Harlem; and the Holland Society, at Harlem, December 28th, 1871, and June 1st, 1872.

Donations for the Library were reported from the Imperial and Royal Academies at St. Petersburg, Turin, and Amsterdam; the Societies at Moscow, Bremen, Bonn, Harlem, the Hague, Leeds, Quebec, and Salem; the Geological Institute at Vienna; the Physical Society and German Geological Society at Berlin; Dr. C. F. Naumann at Leipsic; the Astronomical Observatory at Turin; the Revue Politique; London Nature; Lund University; M. L. de Koninck at Liège; the Royal Astronomical Society; Old and New; American Journal of Science; the American Oriental Society; the Cornell Era; the Franklin Institute; the Medical News; and the Philosophical Society of Washington.

The death of Mrs. Mary Somerville, a member of this Society, aged 92, was announced by the Secretary.

A letter was read by the Secretary from Mr. Gabb, dated Museum of Comparative Zoology, Cambridge, Mass., December 3d, giving additional imformation respecting the date of the emergence of the Isthmus of Panama, in a note to be added to his memoir on the Geology of Santo Domingo.

The Annual Report of the Treasurer was read.

The Annual Report of the Publication Committee was read.

Pending nominations, Nos. 703 to 710, and new nominations, Nos. 711, 712, were read.

The following resolution was offered by Mr. Price and agreed to, and the accompanying letter ordered to be placed upon the minutes:

Resolved, That the Curators be authorized to deliver the Continental Congress Chair to the Mayor, taking an acceptance of it from Councils, that it shall be placed in Independence Hall, subject to be reclaimed at any time by this Society.

To Hon. William S. Stokely, Mayor of the City of Philadelphia:

We herewith deliver into the custody of the City of Philadelphia an Arm Chair used by the Continental Congress, now belonging to the American Philosophical Society, that it may be placed in the Hall of Independence, and accepted by Councils, subject to be at any time reclaimed by said Society.

(Signed) JOSEPH CARSON,
ELIAS DURAND,
HECTOR TYNDALE,
Curators.

December, 1872.

The Librarian stated that a large number of books and brochures needed binding; that the book-cases had again become overcrowded by accessions; that certain classes of books were seldom or never referred to; that the catalogue in MS. of the Theological books and pamphlets was nearly finished; and suggested that the book-cases might be relieved and a benefit be conferred on learning by depositing the Chemical, Mineralogical, and Geological books, temporarily, in the new building of the University of Pennsylvania.

On motion of Mr. Ruschenberger, it was

Resolved, That the Committee on the Library be requested to consider the expediency of depositing in the library of the University of Pennsylvania certain books now in the library of the Society, which are not much called for; and in case they shall deem the same expedient, then to report a plan for carrying the same into effect, which will insure the use of the books to the members of the Society, and also provide for the safe keeping of the books so deposited, and their return to the Society when called for.

And the Society was adjourned.

Stated Meeting, December 20th, 1872.

Present, 13 members.

Vice President, Prof. J. CRESSON, in the Chair.

A letter from the Librarian of the Pennsylvania Historical Society, dated Philadelphia, Dec. 13, was read, requesting the completion of their set of Transactions and Proceedings A. P. S., which on motion was granted, and the Librarian authorized to act accordingly.

Letters of similar import from the Cornell University and State Normal School at Fredonia, were on motion referred to the Publication Committee with power to act.

A letter of envoy was received from Mr. Thomas Bland, New York, 42 Pine Street, Dec. 16th, on the part of Gov. Rawson, of Barbadoes, presenting to the Society's Library a copy of his report on the population of the island.

The death of a member, Mr. Thomas Sully, at Philadelphia, on the 6th ult., aged 89 years, was announced by the Secretary.

The death of a member, Dr. Renè La Roche, at Philadelphia, on the 9th inst., aged 77 years, was announced by Mr. Fraley, and on motion, Dr. Carson was appointed to prepare an obituary notice of the deceased.

The death of a member, Dr. Samuel L. Hollingsworth, at Philadelphia, on the 14th inst., aged 57 years, was announced by Mr. Fraley.

Mr. Cope desired to place on record an abstract, which he communicated orally, of a paper on the Zoological Divisions of the Earth, as proposed by Slater, Huxley and others, giving his preference to that of Slater, and citing the numbers of species, etc., already described.

Dr. Wilcox exhibited a Japanese Magic Mirror, the property of E. C. Bittinger, U. S. N., and carrying on its back side the inscription "Elevation—In the dust." He read two letters written by Prof. John Tyndall to Mr. Alex. Johnson, in answer to a request for an explanation of the physical phenomena of these mirrors, used in the Buddhist cultus.

Prof. Marsh gave a short account of the more remarkable resul's of his explorations in the Rocky Mountains since

1870, viz.: His discovery of the first American fossil pterodactyles, cheiroptera, marsupials, birds with biconcave vertebræ, monkeys (eocene) of low type, and dinoceria, a new order of horned proboscidians with canine teeth.

Prof. Cope dissented from the propriety of at present erecting the proboscidians so discovered into a separate order, merely on the ground of their possessing horns and canines, and gave his reasons.

Prof. Marsh also gave an interesting account of Mr. Clarence King's detection and exposure of the "Arizona Diamond Fraud," and his own observations of the locality, which is actually in Colorado, and not in Arizona. Had the fraud not been exposed by the prompt energy of Mr. King before the setting in of the deep snows, great suffering and loss of life and a vast plunder of property would have ensued.

The Report of the Committee of Finance was read by its Chairman, and the appropriations for the ensuing year recommended therein, were on motion ordered:

Salary of Librarian	$700
Salary of Assistant Librarian	300
Salary of Janitor	100
Binding Books	200
Subscription to Journals	50
Insurance	200
Hall Committee	200
Petty expenses of Librarian	150
Publications in addition to the interest on the Publication Fund	2,500
General Expenses, including the Commissions of the Treasurer	860
	$5,310

Pending nominations, Nos. 703 to 712, and new nominations, 713, 714, were read.

Mr. Fraley reported the receipt of fr. 694.50 from Drexel, Hayes & Co., agents of the Society in Paris, being interest on French Rentes placed to the credit of the Michaux Legacy Fund, of which fund, he explained, $300 had already been paid to the Park Commissioners to defray expenses in establishing the Michaux Grove in the City Park at Fairmount.

The meeting was then adjourned.

COMMUNICATION ON THE DISCOVERY OF NEW ROCKY MOUNTAIN FOSSILS,

MADE BY PROF. O. C. MARSH

At the meeting of the American Philosophical Society, Dec. 20, 1872.

Professor O. C. Marsh, of Yale College, gave a brief account of some of the more important results of his palæontological researches in the Rocky Mountain region during the last three years. He had directed his attention mainly to the extinct vertebrates of the Cretaceous and Tertiary formations, and had obtained more than 200 species new to science, about 150 of which he had already described. Among the new types of fossil vertebrates thus discovered, were Pterodactyls, or Ornithosaurians, the first detected in this country. He had described three species of these from the Cretaceous of Kansas, all of gigantic size. Prof. Cope had subsequently redescribed two of the species in the Proceedings of this Society (Vol. XII. p. 420), but the names *Pterodactylus occidentalis*, Marsh, and *P. ingens*, Marsh, given in the American Journal of Science (Vol. III. p. 241) had priority. A second and quite unexpected discovery of great interest was that of the *Ichthyornidæ*, or cretaceous birds with biconcave vertebræ, two species of which Prof. Marsh had recently described. A third discovery was that of fossil *Cheiroptera*, or Bats, not before observed in this country. The three known species were found in the Eocene of Wyoming. A fourth new type was that of extinct Marsupials, also from the Eocene. A fifth discovery of great importance, was that of fossil *Quadrumana*, several genera and species of which he had found in the Eocene. Prof. Marsh stated that he had obtained indications of fossil Monkeys in this formation more than a year before, but had delayed announcing the discovery until the evidence was conclusive. A sixth new type of animals, and perhaps the most interesting of all, were the gigantic Eocene Mammals, which he had recently assigned to the new order *Dinocerea*. These animals had limb bones somewhat like those of Proboscidians, as stated in the original description of the type species, *Tinoceras anceps*, Marsh. The skull, however, presents a most remarkable combination of characters. It is long and narrow, and supported two, and possibly three, pairs of horns. The top of the skull was concave, and on its lateral and posterior margin there was an enormous crest. There were large decurved canine tusks resembling those of the Walrus, but no upper incisors. The six premolar and molar teeth were quite small. Several species of these remarkable animals have already been described, but at present they cannot all be distinguished with certainty. In addition to the type species already mentioned, Prof. Cope has given the name *Loxolophodon semicinctus*, to a single tooth, which may possibly belong to this group. Dr. Leidy has described a characteristic specimen as *Uintatherium robustum*, and a canine tooth, apparently part of the same animal, under another name. The remarkable feature of the skull in this group was first indicated in the name *Tinoceras*, which the speaker had proposed for one of the genera. Prof. Cope subsequently proposed the name *Eobasileus*, but was mistaken in regard to the main char-

acters of the skull. What he called incisors are canines; and the large horns are not on the frontals, but on maxiliaries. The top of the skull moreover is not convex, but concave, and the occiput is oblique, and not vertical. Prof. Marsh stated that he had described several species of this group, one of the most singular of which, *Dinoceras mirabilis*, Marsh, was represented in the Museum of Yale College by a nearly perfect skeleton, and portions of several others. In all of the species the limb bones differ considerably from those of Proboscidians, while the skull is so totally unlike anything hitherto known, that he could not refer these extinct animals to that group, and hence had proposed for their reception the order *Dinocerea*.

ON A SPECTROSCOPIC OBSERVATION OF THE AURORA OF APRIL 10, 1872.

By Persifor Frazer, Jr.

(*Read before the American Philosophical Society, April* 19, 1872.)

On the night of April 10, 1872, a very beautiful Aurora was seen from Philadelphia, spreading over 25° or 30° of the Northern Heavens.

The night was clear, and the wind was from N. W. and slightly cool. A heavy bank of cloud covered about one-sixth of the horizon to the north, and from the crest of this bank the Aurora seemed to proceed, shooting up fitfully in sprays and bundles to near the zenith, and traversing from west to east and back again with average rapidity. One detached streamer crossed the zenith from N. E. to S. W., and remained permanent in position, giving only occasional fluctuations of light.

Observations were commenced with a Browning angle measuring spectroscope, the light condensed through a 13 foot focus, 9 in. diam. lens.

The observations were made solely with reference to the green line in the Aurora, and the purpose in view was to verify or not the observations of Piazzi Smith in regard to its coincidence with the green hydro-carbon line seen at the base of every candle and illuminating gas-flame.

Four observations gave the following results:

1. Green line of Aurora.....	92°	35′	0″
2. " "	92°	35′	0″
3. " "	92°	48′	0″
4. " "	92°	20′	0″

The line became exceedingly faint during the 3d and 4th observations

so as to present great difficulties in placing the cross wires on it, but as the mean of these deviations, great as it is, is very nearly the two first recorded, I have proposed to let the late observations stand, and rate their value as 1 each, that of each of the first two being called 5.

This would give the value of this line as.....	92°	34′	49.8″
A series of careful observations in the D lines and the F line, gave as a mean of the former.....	91°	52′	30″
And for the latter.....	95°	13′	0″
The angular distance between D and F.....	3°	20′	30″

A curve was projected on the plan now generally adopted by observations on some ten lines, and by reference to this parabola, the mean length of the green line was found to be 563.

It would correspond to 66 of Roscoe or 176.88 Kirchoff. Lines in Rb, and Cs, and Ba, lie very near it, but none exactly coincides with it, nor *is there any absorption line in the Solar Spectrum which does.*

NOTICE OF PROBOSCIANS FROM THE EOCENE OF SOUTHERN WYOMING.

By Edw. D. Cope.

(*Telegram dated Black Buttes, Wyoming, August* 17, 1872, *read by the Secretary at the meeting of the American Philosophical Society, September* 20*th*, 1872.)

I have discovered in Southern Wyoming the following species: Loxolophodon, Cope. Incisor one, one canine tusk; premolars four, with one crescent and inner tubercle; molars two; size gigantic. L. *cornutus;* horns tripedral, cylindric; nasals with short convex lobes. L. *furcatus,* nasals with long spatulate lobes. L. *pressicornis,* horns compressed subacuminate.

(Signed) Edward D. Cope,
U. S. Geological Survey.

[*Note by the Secretary.*—The above telegram was so badly transmitted by the operators as to be read with difficulty, and the precise forms of the specific names could not be certified until the return of Prof. Cope from the field.]

Obituary Notice of Edward Miller, Civil Engineer.

Prepared at the request of the American Philosophical Society, and read at a meeting of the Society, April 5, 1872.

By Solomon W. Roberts, Civil Engineer.

Edward Miller was born in Philadelphia on the 6th of January, 1811.

He was the third son of William Miller, who was the Secretary of the Philadelphia Marine Insurance Company, and had been Commissioner of the Revenue of the United States at the City of Washington. He was a gentleman of the old school, remarkable for his punctilious politeness, and for a high sense of honor; and was held in high esteem by many prominent citizens of Philadelphia, and in particular by Mr. Nicholas Biddle, with whom he was very intimate. Mr. William Miller and his family were connected with the first Presbyterian Church of Philadelphia for many years.

Edward Miller was educated at the University of Pennsylvania, where he graduated, with Mathematical Honor, when seventeen years of age. Immediately afterwards he entered the Engineer Corps on the Lehigh Canal, of which Canvass White was the Chief Engineer. Mr. White had been one of the Principal Engineers of the Erie Canal of New York, and he was a gentleman of fine character and much experience. He had made pedestrian tours along the lines of the principal canals of Great Britain, and he was a man of sterling integrity and of great industry. When Edward Miller joined the corps, the Resident Engineer was Sylvester Welch, a man of remarkable energy of character, who planned the Portage Railroad and directed its construction across the Allegheny Mountain, and who was afterwards the Chief Engineer of the State of Kentucky. With him was his brother, Ashbel Welch, since the Chief Engineer of various important works in New Jersey, and for several years, until the leasing of the lines, the President of the United Companies of that State. On the Lehigh at the same time were W. Milnor Roberts, now the Chief Engineer of the Northern Pacific Railroad; Solomon W. Roberts, now Chief Engineer and Superintendent of the North Pennsylvania Railroad; A. B. Warford, Geo. E. Hoffman, Benjamin Aycrigg, and several other well known engineers. It was a good school.

Canvass White had been an officer of volunteers in the war of 1812, and had been badly wounded at Fort Erie. He was a strict disciplinarian, and set a fine example of conscientious discharge of duty, even when suffering from ill health and much bodily weakness. Henry Clay, when recommending him for Engineer of the Chesapeake and Ohio Canal, said: "No man is more competent, no man more capable; and while your faith in his ability and fidelity increases, your friendship will grow into affection." He died in 1834 of pulmonary disease, when 44 years of age, and is buried at Princeton, New Jersey, where he had resided as Chief Engineer of the Delaware and Raritan Canal.

The principal manager of the business of the Lehigh Canal and Navigation Company at that time, was Josiah White, a member of the Society of Friends; a man whose abilities and great public services in developing the resources of Pennsylvania, were worthy of a more fitting memorial than they have yet received.

From the time when Edward Miller joined the corps at Bethlehem, on the Lehigh, in 1828, until the canal was completed in the following year, he was much liked by his comrades, and an intimacy grew up between him and the writer of this notice, which lasted without interruption until his death, a period of more than forty years. In the autumn of 1829, they entered together the service of the State of Pennsylvania, on the western division of the State Canal, of which Sylvester Welch had been appointed the Principal Engineer.

That work was finished in December, 1830, and early in 1831 Edward Miller went abroad and passed some months in England, where he carefully examined the Liverpool and Manchester, the Cromford and High Peak, and other railways in Great Britain. He was provided with excellent introductory letters, and he acquired a large amount of valuable professional knowledge. Soon after his return home, Sylvester Welch, who had become the Principal Engineer of the Portage Railroad over the Allegheny Mountain, appointed Edward Miller to be his Principal Assistant in charge of the Machinery of the Inclined Planes. Mr. Miller designed the stationary engines and other machinery for ten inclined planes, and superintended their construction in Pittsburg. The plans were novel and ingenious, and the rapid manner in which the planes on the mountain were worked, as compared with those elsewhere, showed their great superiority. In the spring of 1834 the railroad over the mountain was opened for public use, the rise from the canal-basin at Hollidaysburg to the summit being 1,400 feet in a little over ten miles. The work attracted much notice, and many persons of distinction visited it. It served its purpose until it was superseded by the improved line of the Pennsylvania Railroad.

Throughout his career, Edward Miller illustrated the advantages of literary and scientific training to a man of business. He surrounded himself with good books and made good use of them. He turned his attention to Geology, and studied it with reference to its influence upon topography, and upon the contour lines of the country in which he was engaged in railroad explorations and locations, and especially with reference to the region of the Allegheny Mountains in Pennsylvania, of which he traced a crest line for more than forty miles. Soon after he grew up to manhood he wrote an essay on this subject for publication.

The first work of which he had the independent charge as Chief Engineer, was the Catawissa Railroad. At that time locomotive engines had been but a few years in use for miscellaneous traffic; they were much lighter and less powerful than those now used, and high speeds and long trains were very little known. The ponderous engines, weighing thirty

or forty tons, with steel tires and steel fire-boxes, burning anthracite coal, and rushing along over varying grades with a speed and a power which continue to impress the imagination even of those whose daily duty it is to direct their course, had then no existence.

The Catawissa Railroad has a summit-tunnel about 1,200 feet long, excavated through rock. The rise from the Susquehanna at Catawissa to the tunnel on the head-waters of the Little Schuylkill, is very nearly 1,000 feet in about thirty miles. Mr. Miller fitted his line to the ground with very great care, and in such a way that the road has no grade exceeding thirty-three feet in a mile, so as to economize locomotive power to the greatest possible extent. This necessitated the building of several very high bridges to carry the grade across lateral ravines entering the main valley. This road continues to be in successful use. The location was a very bold one, nothing like it having been attempted in the country before, and it showed a very considerable degree of originalty and self-reliance on the part of the young engineer who made it.

In June, 1836, while living at Catawissa, Mr. Miller was happily married to Miss Jessie Patterson Imbrie, of Philadelphia. His wife survives him with a large family of children, and their eldest son, Mr. James Imbrie Miller, now holds a high position in British India, as Chief Engineer of the Government Railways in Rajpootana, a large district of Central India, with the rank of Lieutenant-Colonel of Engineers.

Soon after his marriage, Edward Miller was, for some time, the Chief Engineer of the Morris Canal of New Jersey.

Before the completion of the Catawissa Railroad, he left it to become Chief Engineer of the Sunbury and Erie Railroad Company, of which Nicholas Biddle was then the President. He proceeded to explore the country between Sunbury and Erie, much of which was a wilderness. It was said at the time, that in the wildest part of it there was but one house near the line for sixty miles. A considerable time was occupied in preliminary surveys, but the construction of the work did not go on until long after, on account of the failure of the United States Bank and the temporary collapse of credit that ensued.

The people residing in the southern tier of counties in the State of New York, were resolutely bent on having a railroad from the Hudson River to Lake Erie, to rival the Erie Canal. A charter was obtained and the work undertaken. Thus arose the New York and Erie Railroad Company, which has had such an extraordinary history since, a history which, to one familiar with it, seems like a romance.

By its charter the company was prohibited from locating any part of its road outside of the territorial limits of the State of New York. The long line was cut up into several parts, with independent Engineers upon each, and confusion followed as a matter of course. Edward Miller was employed as a Consulting Engineer to write a report upon what was going on. This he did so much to the satisfaction of the Board of Directors, that he was soon after appointed Chief Engineer of the whole line from

the Hudson to Lake Erie. When it is considered that he was a citizen of Pennsylvania, and only thirty years of age, it is remarkable that he should have received such an appointment.

The location of the railroad was materially changed, additional legislation was obtained, a part of the line was laid within the limits of Pennsylvania, on the Upper Delaware; and Mr. Miller continued to be the Chief Engineer for about three years, and until the work was suspended for the want of funds. The first division of the road was opened for public use while he had charge of it.

It may be remarked, in this connection, that a great change has come over the general tenor of legislation in the several States of the Union, on the subject of internal improvements.

Men change and die, but the mountain ranges remain and the streams flow on in their old channels. The arbitrary lines drawn upon the map as political divisions, cease, more and more, to act as barriers to obstruct the construction and use of railroads, which the people feel that they need to facilitate their free intercommunication, and thus the railroads of the country become one of the most powerful means of securing a more perfect Union.

After leaving the New York and Erie Road, Mr. Miller returned to Philadelphia, and became President of the Harrisburg and Lancaster Company, which post he held for two years, and while holding it he visited England as financial agent of the Company. In 1845 he was the Chief Engineer of the enlargement of the Schuylkill Navigation, a work by which the tonnage of the boats upon the Schuylkill River and Canal has been considerably more than doubled.

On the 18th April, 1845, Edward Miller was elected a member of the American Philosophical Society.

In 1856, the Pennsylvania Railroad Company was chartered. The prompt construction of a continuous railroad from Philadelphia to Pittsburg was demanded by public opinion; and, in the face of much opposition, the City of Philadelphia, in its corporate capacity, subscribed five millions of dollars to the stock of the company.

Mr. John Edgar Thomson, now the distinguished President of that powerful and prosperous corporation, was appointed its Chief Engineer. Mr. Thomson is a native of Pennsylvania, born in Delaware county, and his great success as a railroad engineer in Georgia, recommended him for his new post of professional honor and responsibility. How worthily he was to fill it is best shown by the annual reports of the Pennsylvania Railroad Company for the last twenty-five years. Edward Miller became the Associate Engineer of the Western Division, the most difficult part of the line, and under his supervision the surveys and location of the road from Altoona to Pittsburg were made, under Mr. Thomson as Chief Engineer. After Mr. Thomson became President of the Company, Mr. Miller succeeded him as Chief Engineer.

How efficiently these gentlemen aided each other, and thus promoted

the great interests confided to their care; with what freedom from professional jealousies they acted, and what magnanimity characterized their intercourse, is well known to the writer of this imperfect tribute to the memory of one whose loss we now deplore, and who considers it to be a worthy example to young men entering upon the arduous life of a Civil Engineer.

Mr. Miller remained in the service of the Pennsylvania Railroad Company for about six years, and in 1852 he visited England on business of that corporation.

In February, 1853, he became the Chief Engineer of the North Pennsylvania Railroad, and continued upon that line until June, 1856, in that year being President of the Company. He located the railroad from Philadelphia to Bethlehem, and part of it was completed while under his charge. A continuous line was also located from Bethlehem to the State line of New York at Waverley, and various other surveys were made to the Delaware Water Gap and elsewhere.

In 1856, Edward Miller removed to Missouri, having been appointed Chief Engineer of the Pacific Railroad of that State. He held that post for a few years; and, having gone to reside on a large farm near the Missouri River, about six miles from the Kansas line, the war broke out, and he found himself with a large family in a position of great peril. The progress of the railroad had stopped, and a terrible, irregular warfare filled all Western Missouri with fear. After enduring the evils of this position for a time, Mr. Miller returned to Philadelphia, leaving that home in the West which he had done much to improve, and which had for a while lost its value.

Although many millions of dollars had been disbursed under his direction on various public works, his accumulations, after many years of labor, had not been large. He was proud of his profession, looking upon it as the art of directing the great sources of power in nature to the use and benefit of man, and he considered the Civil Engineer to be not only the interpreter between the man of science and the mechanic, but also a captain of industry, bound in honor to set a good example to those working under him of all uprightness and integrity.

He had reached the age of fifty years, and he felt the importance of making a more adequate provision for his family. Through the kind assistance of Mr. John Edgar Thompson, he became a partner in a large contract for the completion of the Philadelphia and Erie Railroad, which proved to be profitable, and he was afterwards interested as a contractor on the Warren and Franklin and Kansas and Pacific Railroad. The favorable results of these undertakings enabled him to leave his family in easy circumstances.

In January, 1871, he was sixty years old, and about that time he found himself suffering from serious disease, the symptoms of which had begun to develop themselves some time before. An internal tumor, of a cancerous nature, was found to exist and to be increasing, and the resources of

medical science and skill failed to remove it. He lived for about a year, after the nature of his disease became known to him, and at times he suffered great pain. In the latter part of the time he could take but little food, and his strong frame, more than six feet in hei ·ht, became very much emaciated. He was nursed with the tenderest care ; and a supply of the bark of the Cundurango plant from South America was obtained for him, which has been highly spoken of as a remedy for cancerous diseases, but which failed in this case.

The Christian character of Edward Miller was beautifully exhibited in his last illness, and he was a fine example of "the power of religion upon the mind in retirement, affliction, and at the approach of death." He had long been a member and an elder of the Presbyterian Church. Although a person of very positive opinions, and free in the expression of them, he was a broad-minded man, and some of his nearest friends were not of his religious communion. At the last, he passed away serenely to his final rest, full of Christian faith and hope.

He died on the first of February, 1872, in the sixty-second year of his age, at his house in West Philadelphia, and was buried at Woodlands Cemetery.

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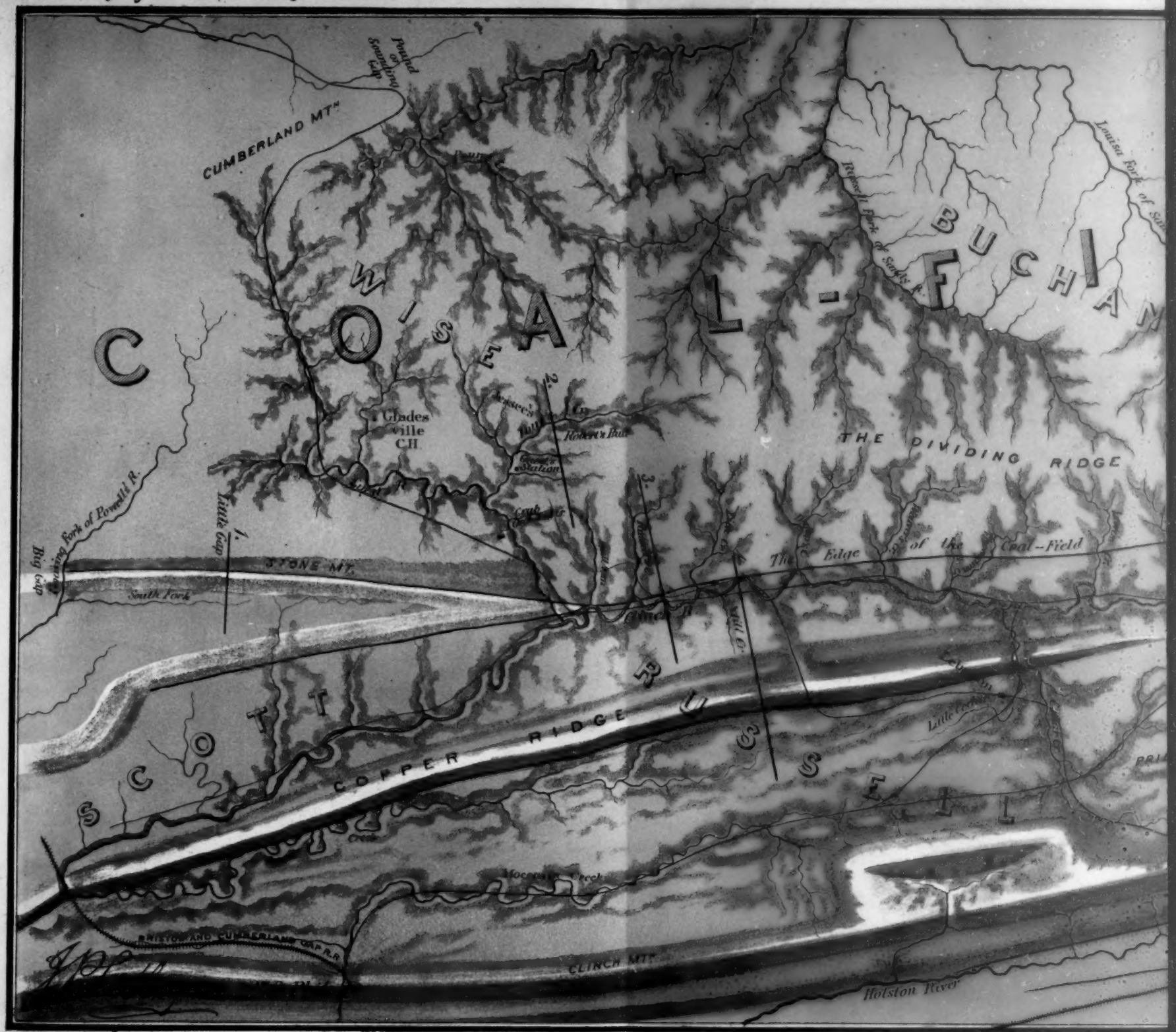
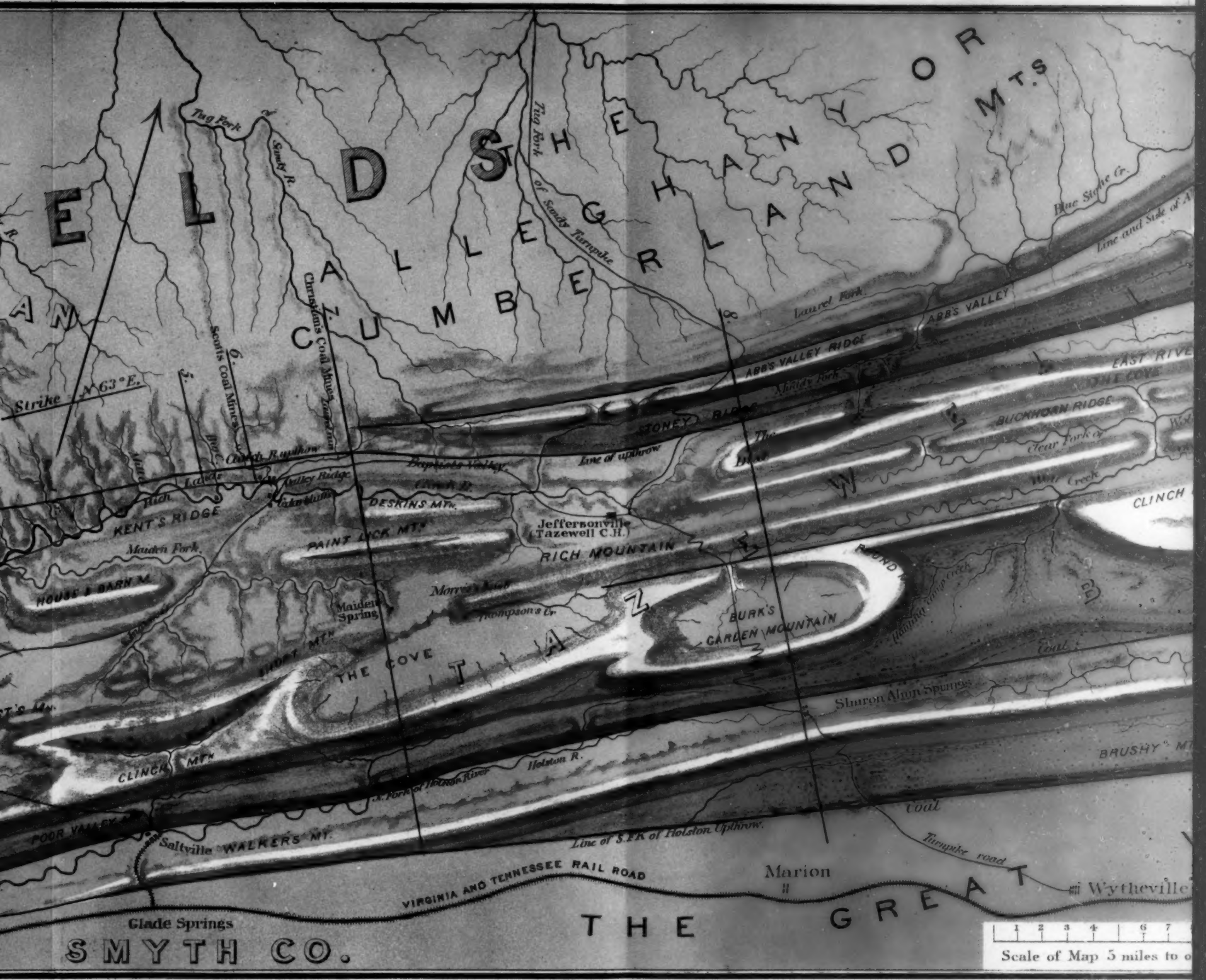
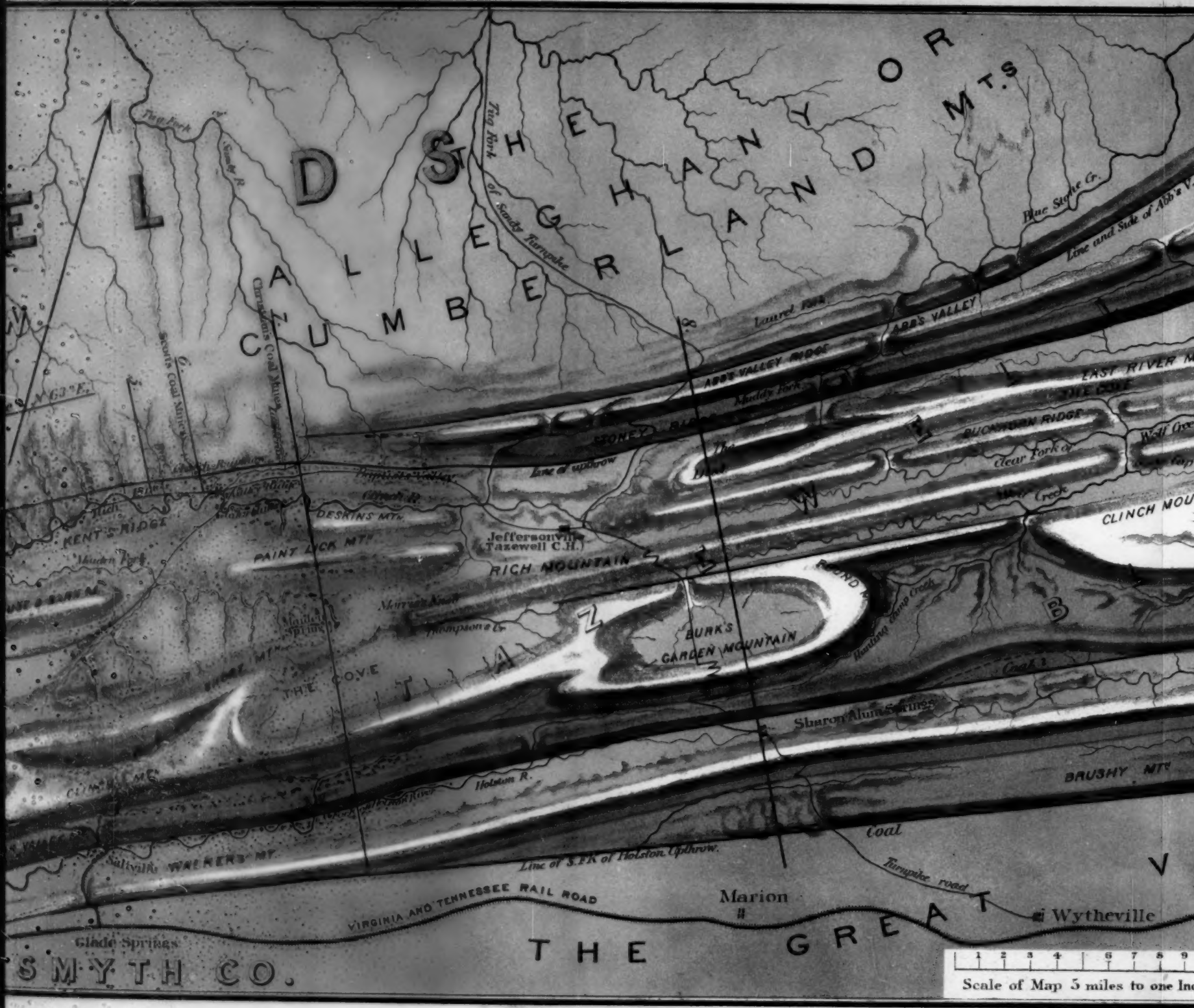
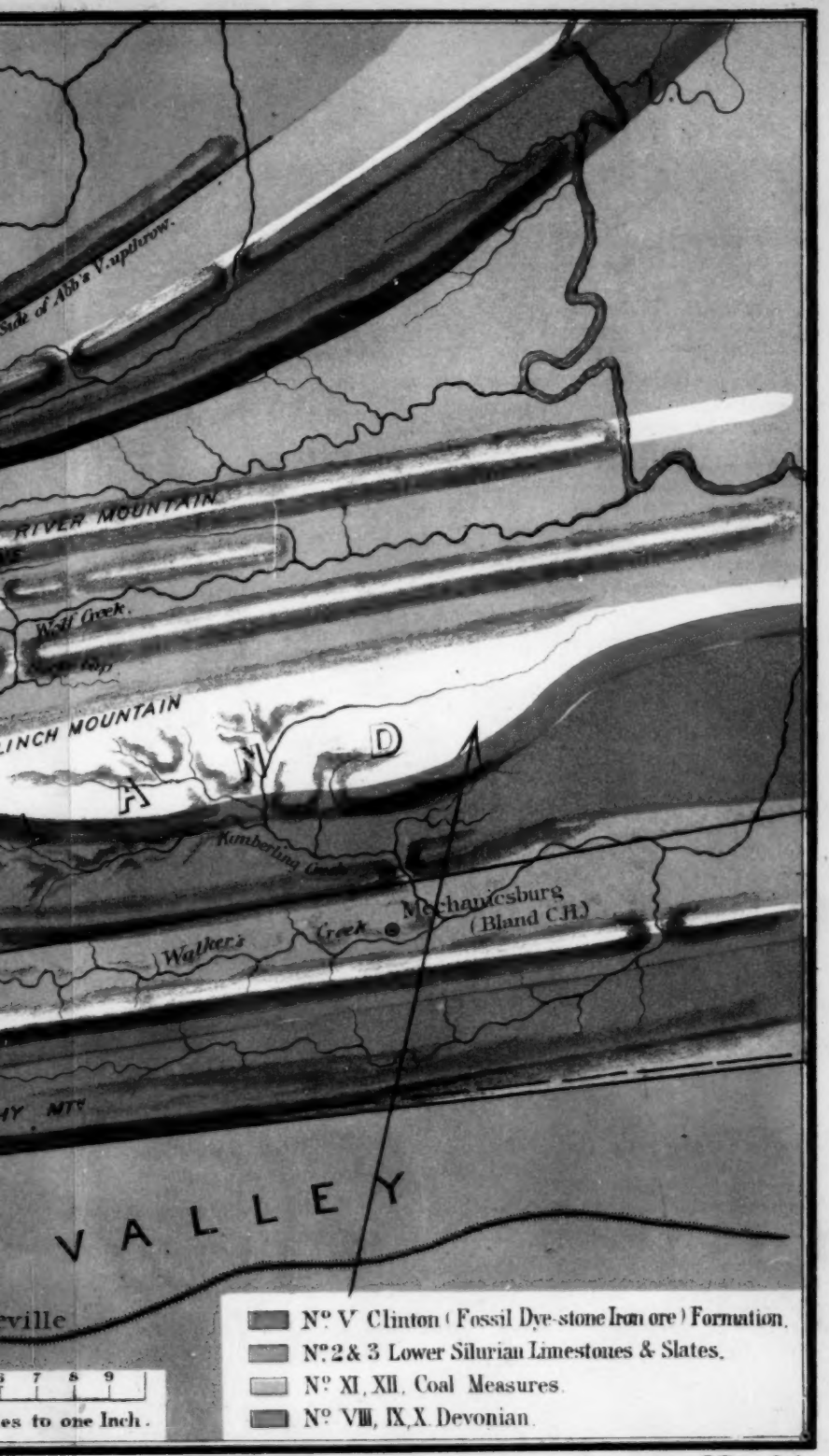

CUMBERLAND MT.
Pound or Sounding Gap
COAL-BUCHANAN
Russell Fork of Sandy R.
Louisa Fork of Sandy
Glades ville C.H.
THE DIVIDING RIDGE
Big Cave
Little Gap
STONE MT.
South Fork
The Edge of the Coal-Field
SCOTT
COPPER RIDGE
RUSSELL
Little Cedar
BRISTOL AND CUMBERLAND GAP R.R.
CLINCH MT.
Holston River

Louisa Fork of Sandy R.
Russell Fork of Sandy R.
BUCHANAN
THE DIVIDING RIDGE
Strike
Holston River


ELDERS
ALLEGHANY OR CUMBERLAND MTS
THE GREAT VALLEY
Tug Fork of Sandy
Sandy R.
Tug Fork of Sandy Turnpike
Laurel Fork
ABB'S VALLEY
ABB'S VALLEY RIDGE
Line and Side of A
Line State Gr.
EAST RIVE
THE COVE
BUCKHORN RIDGE
Clear Fork of
Strike N 63° E.
Scotts Coal Mines
Christians Coal Mines
Line of upthrow
STONEY RIDGE
Big Creek
Dry Fork
Dripping Spring Valley
Cedar R.
Cedar Valley Ridge
Cedar Mills
DESKINS MTN.
CLINCH
KENT'S RIDGE
Maiden Fork.
PAINT LICK MTN
Jeffersonville (Tazewell C.H.)
RICH MOUNTAIN
HOUSE & BARN M.
Morrow's Road
Maiden Spring
Thompson's Gr.
BURK'S GARDEN MOUNTAIN
Flannel camp Creek
Coal
Sharon Alum Springs
BRUSHY MT
CLINCH MTN
N. Fork of Holston River
Holston R.
POOR VALLEY
Saltville
WALKER'S MT.
Line of S.F.K. of Holston Uphrow.
Coal
Turnpike road
VIRGINIA AND TENNESSEE RAIL ROAD
Marion
Wytheville
Glade Springs
SMYTH CO.
Scale of Map 5 miles to o


ALLEGHANY MTS.
CUMBERLAND
Tug Fork of Sandy Turnpike
Laurel Fork
ABB'S VALLEY
ABB'S VALLEY RIDGE
Maiden Fork
BUCKHORN RIDGE
Dear Fork of
Line of upthrow
DESKINS MTN
Jeffersonville
Tazewell C.H.
KENT'S RIDGE
PAINT LICK MTN
RICH MOUNTAIN
BURK'S GARDEN MOUNTAIN
Hunting Camp Creek
Sharon Alum Springs
THE COVE
BRUSHY MTN
Holston R.
Coal
Line of S.F.K of Holston Upthrow.
Turnpike road
SALTVILLE
WALKERS MT.
VIRGINIA AND TENNESSEE RAIL ROAD
Marion
Wytheville
Glade Springs
SMYTH CO.
THE GREAT
Scale of Map 5 miles to one Inch


Side of Abb's V. upthrow.
RIVER MOUNTAIN
Wolf Creek.
LINCH MOUNTAIN
A N D
Walker's Creek
Mechanicsburg (Bland C.H.)
VALLEY
No. V Clinton (Fossil Dye-stone Iron ore) Formation.
No. 2 & 3 Lower Silurian Limestones & Slates.
No. XI, XII. Coal Measures.
No. VIII, IX, X. Devonian.
es to one Inch.

J. Bien Lith.

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[*To be continued in No.* 89.]

The first edition of this number of the Society's Proceedings, and of the first three Articles of the current volume of Transactions, was unfortunately lost in the burning of Messrs. M'Calla & Stavely's Printing Office, on Sunday, May 19th. The accident has caused some delay in the appearance of this Number. The MSS. of Prof. Persifor Frazer's paper entitled: Spectroscopic Observations of the Aurora of February 4th, as well as the MSS. of Mr. Price's Record of the Aurora, were destroyed in the same manner.

There are still many Members of the Society whose Cartes de Visite would find room in the Album, to complete the Record of its Membership.